

ATOMIC ENERGY OF CANADA LIMITED

# Ascent

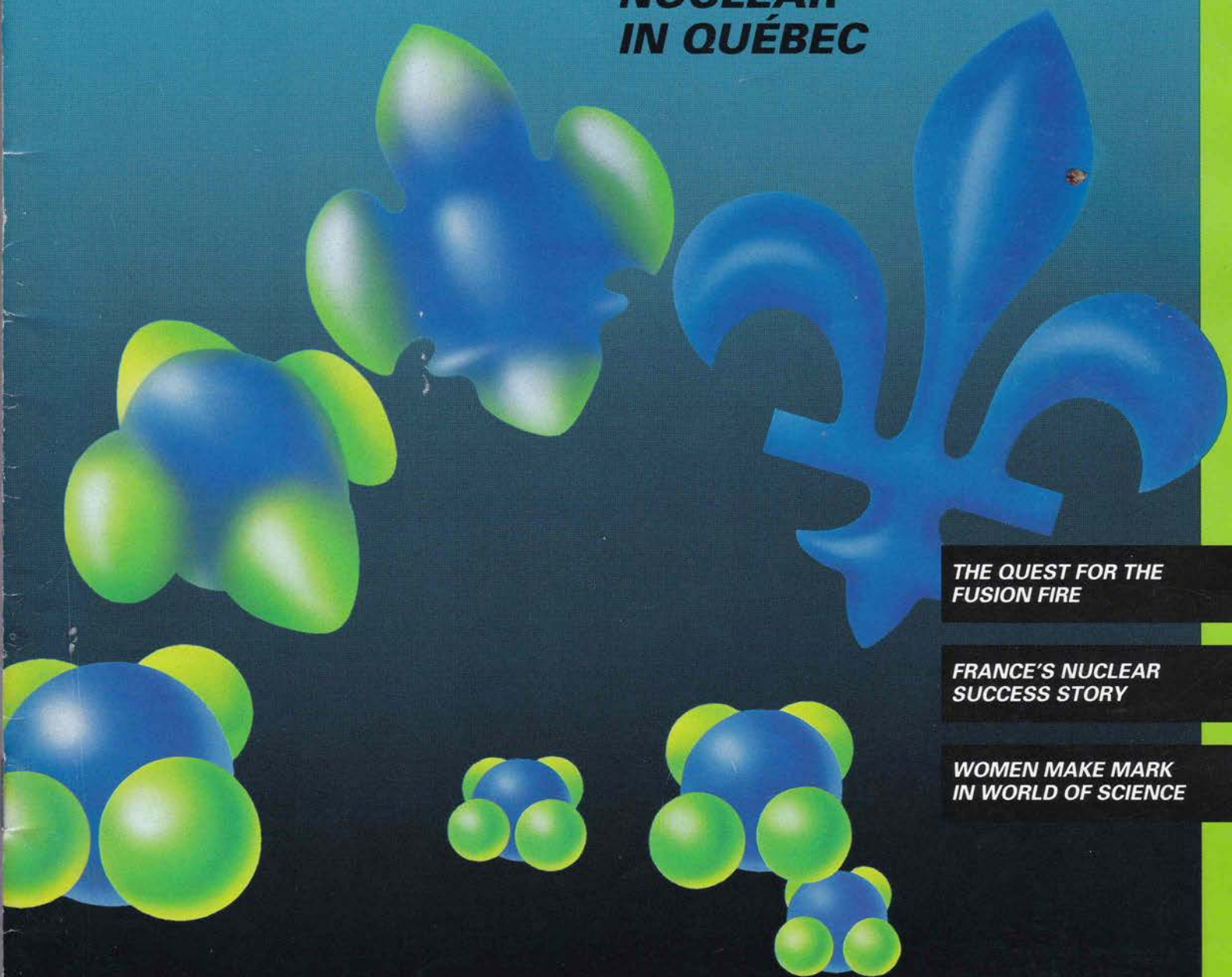
VOLUME 8 NUMBER 3 FALL 1989 \$4.00

## NUCLEAR IN QUÉBEC

THE QUEST FOR THE  
FUSION FIRE

FRANCE'S NUCLEAR  
SUCCESS STORY

WOMEN MAKE MARK  
IN WORLD OF SCIENCE





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*"Looking behind the possible loss of sufficient harnessed energy, we see that mankind can be destroyed by something much simpler to propagate, namely mistrust."*



— W.B. Lewis (1908-1987)  
Father of the CANDU  
power plant

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## About the cover

The concept of the cover, by Montréal illustrator Tom Carbray, depicts what many industry spokespersons are predicting will be a revival of nuclear fortunes in Québec: an atom, consisting of a nucleus surrounded by electrons, is being transformed into a fleur-de-lis, the symbol for Québec. "I wanted to recreate the science textbook style while adding a touch of creativity," Carbray says. His concept was carried out by airbrush artist David McGregor of Ottawa. An airbrush, which is basically an ink atomiser, was used to produce the shady yet precise tones of the illustration.

# Ascent

## Inside the next issue

In the next issue of **Ascent**, look for articles on nuclear waste disposal.



## Cover story . . . . . 6

The achievements of the nuclear industry in Québec are not well known. Yet the province has an operating CANDU reactor, major research facilities in fusion, nuclear medicine, and food irradiation, and a number of companies plugged into international nuclear markets. While nuclear is not big business in Québec now, the industry could see an expansion of activity in coming years.



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People in Ontario want a reliable, non-polluting source of electricity, according to Senator Michael Kirby, vice-president of Goldfarb Consultants.

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AECL preparing plan for Indonesian development; Environmental company seeks global markets; Nuclear increases share of electricity generation.

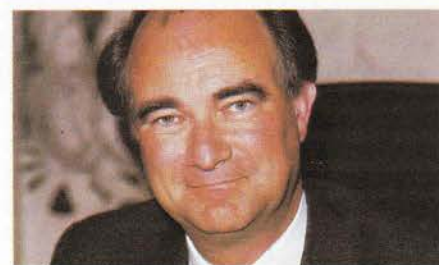
## Forefront . . . . . 13

Fusion has long been held out as the ultimate answer to the world's growing energy needs. But harnessing here on Earth the same energy source that powers the sun is proving no easy task.



## International . . . . . 19

Nuclear power plants supply 70 percent of France's electricity, the highest percentage of any country in the world. François Bujon de l'Estang, France's ambassador to Canada, explains why the French nuclear program has been so successful.

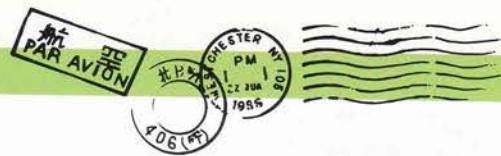


## Human energy . . . . . 21

While women scientists are few in number, their ranks are growing and their achievements are considerable. **Ascent** profiles nine women who are making their mark in the world of science.







*The effect of carbon dioxide and other gases on the environment concerns readers.*

### Conflicting statistics

In an earlier publication of *Ascent* (Volume 8, Number 1, Spring 1989), I found two articles regarding nuclear power and environmental concerns. In the first, "The environmental case for nuclear power," it is stated in the table on page 15 that a 1,000-megawatt coal-fired power station consumes 3,000,000 tons of fuel per year and emits 7,000,000 tons of carbon dioxide. In the second article, "Energy and the environment: a precarious balance," there are different figures on page 28. Here the same power station burns 3,800,000 tonnes of fuel per year and emits 14,000,000 tonnes of carbon dioxide.

As we all know, environmental concerns and nuclear power are very delicate matters with the public. It was a good point to emphasize that nuclear-generated power has some advantages over conventionally generated power. Hence it is important that contradictory figures not be published, especially in *Ascent*, which is a publication of Atomic Energy of Canada Limited.

Gerd Wengler  
Saskatoon, Saskatchewan

#### Editor's note:

The numbers differ because they were taken from different sources. The figures in the table included with the article "The environmental case for nuclear power" were taken from the Nuclear Energy Report 13 produced by the United Kingdom's Watt Commission on Energy. Jim Megaw, in his article "Energy and the environment: a precarious balance," derived his own figures. He explains: "It is difficult to be precise

because emissions will depend on the efficiency of the station (and its age), and on the quality of coal burned. My estimate is certainly an upper estimate, for I took the fuel consumption to be 3.8 million tonnes (a generally accepted figure for a 1,000-megawatt station) and assumed that it was all carbon and all went to carbon dioxide. This of course neglected the ash (about one million tonnes) and any sulphur dioxide formed from the sulphur count of the coal. It can be calculated that a 1,000-megawatt station operating at 30 percent efficiency would require 3.2 million tonnes of carbon per year. This would give rise to 12 million tonnes of carbon dioxide per year. If the station was 40 percent efficient, 2.4 million tonnes of carbon would be required and the output of carbon dioxide would be about 9 million tonnes per year."

Whatever figures are used, however, the fact remains that coal-fired generating plants emit a large amount of waste into the atmosphere.

### Proud of nuclear

We should all be proud of our achievements in the nuclear field. I find it difficult to understand why some groups spend so much effort on awakening unreasonable fears in the public, for example, with the propaganda surrounding the Three Mile Island incident. The saddest part is that they have succeeded.

Clearly pollution is a serious problem and must be resolved, but it cannot be resolved by stopping progress. Scientific research holds the answers.

Many people on the planet are now

suffering and dying for no reason. Nuclear development is one means by which we can establish a fairer situation that will enable every individual to reach full potential.

The short history of the nuclear industry paints a very clear picture of humanity and its attitudes. I view it with a mixture of joy and sadness. It is a story of effort, discovery, achievement, and hope. But it also contains much fear, selfishness, and manipulation.

When fear conquers hope, suffering worsens. The nuclear industry must be developed in Canada and throughout the world with hard work and intelligence.

Daniel Ricard  
Montréal, Québec

### Good work

I found your Spring 1989 (Volume 8, Number 1) issue very interesting. Keep up the good work. With this issue, you have certainly made more people aware of the environmental impact of energy production on the survival of our planet.

Présille Roberge Ferland  
Sainte-Anne-de-la-Rochelle, Québec

### The real enemy

Dr. Megaw's excellent article (Volume 8, Number 1) makes a good case for nuclear power generation, but he would underline the real issue better if he concentrated on fuel-burning generating stations as the real target. All the other options no doubt have difficulties, as has nuclear energy, but they will not destroy thousands of lakes and forests nor melt the polar ice caps. Fossil-fueled energy is the enemy.

Aswan and Kariba dams have caused serious problems, but the problems would be easily solved just by opening the dams; it appears that the benefits are considered to outweigh the problems. Dr. Megaw says the James Bay project is now recognized as environmentally dangerous. By whom is it so recognized? There is a serious problem with mercury pollution from flooded muskeg (which is not a permanent problem), but consider the waste produced by coal-fired plants generating the same amount of electricity, and take your choice.

The important point is that every alternative way of producing power that reduces the amount of fossil fuel burned is environmentally desirable.

Robert Sproule  
Montréal, Québec



## THE HYDRO MYSTIQUE IN QUÉBEC

**B**ecause of its plentiful hydroelectric resources, Québec has not had to adopt a large-scale nuclear power program, although one plant, Gentilly-2, has been operating in the Mauricie region since 1983.

With most of the province's productive waterways already tapped, however, the potential for profitably harnessing additional hydraulic resources is fading. Meanwhile, the demand for electricity in Québec continues to grow at more than six percent annually. And this growth in demand for electricity, needed to fuel Québec's continued economic development, will not likely diminish in the future.

The time is fast approaching when Québécois will have to consider other means of generating electricity. Will they opt to burn coal or natural gas? Those courses of action seem unlikely, since burning fossil fuels contributes directly to acid rain and the greenhouse effect. Or will Québécois embrace solar and wind energy alternatives? Although possible options, these energy sources may never advance to the point where they could produce the large amounts of power needed to supply cities and industrial complexes.

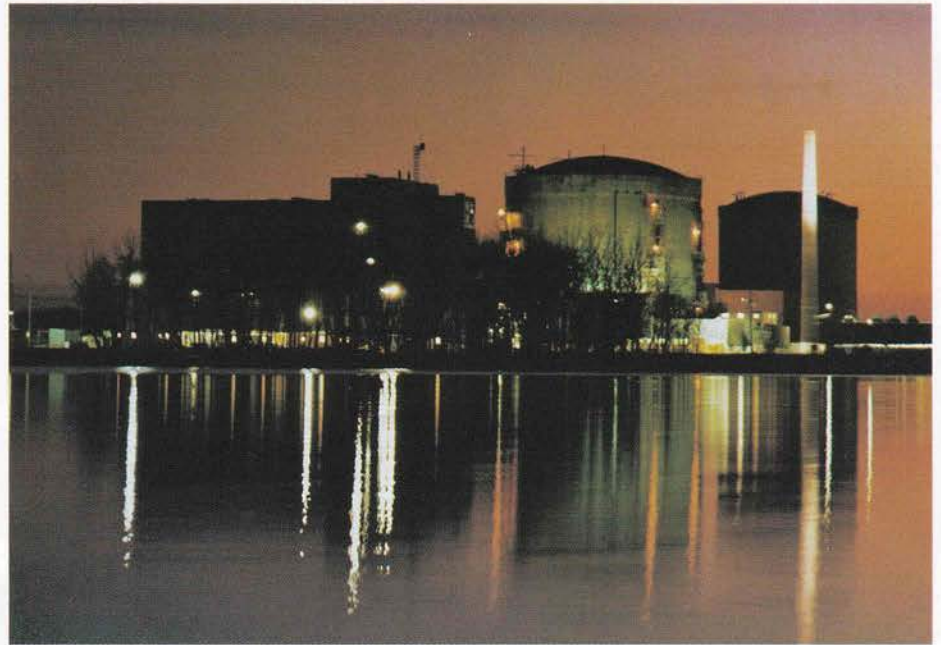
### Viable alternative

The most viable alternative, during the next few decades at least, is nuclear fission power plants. Thermonuclear fusion plants, at best, will not be ready for commercialization until well into the next century.

It has historically taken about 10 years from the time a site is chosen until a nuclear power plant begins operation. The new CANDU 3 reactor will shorten this period to about five years.

In the very near future, Québec will have to debate nuclear issues already confronted by most of the industrialized world. The time to examine these issues and other alternatives to hydroelectricity may be extremely brief.

Yet, it appears that few people in Québec are familiar with the alternatives. A survey conducted by Hydro-Québec in 1986 indicated that only 20 percent of Québec residents consider themselves well informed about nuclear energy. This survey also revealed that less than half of Québécois



*The Gentilly-2 nuclear power station was ranked 12th in the world in 1988 among 272 reactors rated at 500 megawatts or more.*

knew that a nuclear plant is operating in the province and, in fact, that one-quarter of the population firmly believe there is none. Of the people who were aware that there was a nuclear power plant in the province, only half could indicate its approximate location or state its name.

For many Québécois, then, it will come as something of a news flash to "announce" that the Gentilly-2 nuclear plant operates — and has since 1983 — at Bécancour, 30 kilometres east of Trois-Rivières. The plant, in fact, is one of the most efficient in the world, ranking 12th in the world among a total of 272 reactors rated at 500 megawatts or more.

Ontario, Québec's neighboring province and traditional industrial competitor, opted for nuclear power about 30 years ago. Now, CANDU nuclear generating stations provide nearly 50 percent of the electricity consumed in Ontario. Canada's economic heartland is already largely powered by nuclear energy, and that reliance on nuclear power likely will continue to grow in the future.

By the year 2000, if the demand for electricity continues to increase at the present rate and the power from new

hydroelectric dams becomes more expensive than from CANDU plants, Québec homeowners and industries could find themselves paying more for their electricity than their neighbors in Ontario.

In Québec, however, nuclear converts are preaching in a hydraulic desert. Hydroelectricity has taken on an almost mythical aura in Québec. It is the foremost symbol of the Quiet Revolution and of Québec know-how. But once the major hydraulic resources have been exhausted, the tide may turn in favor of nuclear. As an economic and environmental answer to the province's growing energy needs, nuclear power could suddenly become the pet project of the government of the day.

Québec must examine the nuclear energy option in a calm and rational manner as soon as possible, before the need for additional power plants becomes urgent. ■

Benoit Legault



# THE DAWN OF A NUCLEAR REVIVAL

*Modern-day Québec, with its legions of engineers and entrepreneurs, has everything it takes to meet the challenges of nuclear power.*

by Benoit Legault

Between Montréal and Québec City, on the southern shores of the St. Lawrence River at Bécancour, a 685-megawatt CANDU nuclear power station employs 668 people and generates enough electricity to supply the needs of a city the size of Trois-Rivières. Yet, according to a Hydro-Québec survey, less than half of Québécois even know that the station exists.

Nor may many Québec residents be aware that the province is also the site of a world-class fusion reactor program at Hydro-Québec's research centre at Varennes; or that the Canadian Irradiation Centre in Laval is one of the country's major R&D facilities on food irradiation (see box); or that the province is a leader in the application of nuclear medicine at such locations as the Sherbrooke University Hospital and the Hôtel-Dieu and Saint-Luc Hospitals in Montréal. Indeed, in 1969, Québec was the first location in the world to officially recognize nuclear medicine as a specialty in the medical profession.

Perhaps unknown as well is that a number of Québec companies — Atomic Energy of Canada Limited's (AECL's)

CANDU Operations in Montréal, Canatom, MPB Technologies Inc., and The MIL Group — are giving Québec a toehold in the international nuclear industry.

Québec's nuclear roots, in fact, go deep. Montréal was the site of the first major nuclear fission research laboratory in Canada. The facility, set up in 1943 at the

University of Montréal, operated for only a short period of time, but it laid the foundations for the heavy-water reactor which would later emerge as the CANDU nuclear power reactor.

While the nuclear industry's achievements in Québec are not well known, overshadowed in large measure by the province's massive commitment to hydroelectric power, the industry nonetheless plays an important, albeit low-profile, role in the province's economic infrastructure.

Indeed, many in the industry are predicting a revival of nuclear's fortunes in

particular could become a centre for nuclear research and development. "The quality of life in Montréal is very good and that is a decisive factor in attracting international experts vital to our work," he says.

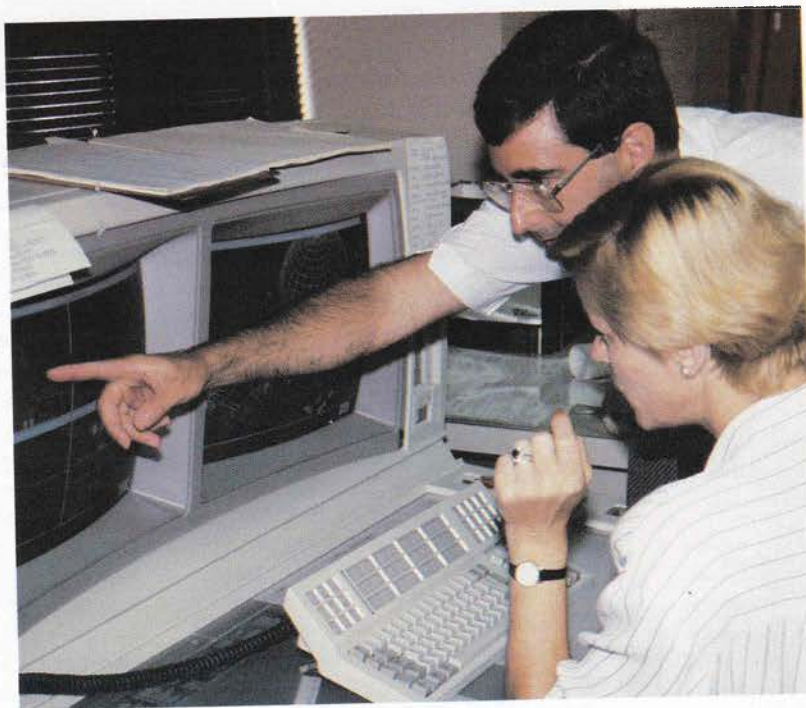
"Montréal is also a major engineering centre; there are more engineers here than anywhere else in Canada."

Despite their high standing in their home province, Québec engineers have not been as successful in breaking into the job market in other parts of Canada. "It is true that French-speaking engineers from our province are rarely sought by firms outside

Québec," says Daniel Rozon, director of the Institut de génie énergétique (energy engineering) of the École polytechnique de Montréal.

Rozon, who worked on CANDU nuclear reactor design from 1971 to 1973 at CANDU Operations headquarters in Mississauga, Ontario, says that it simply doesn't occur to leading scientists outside Québec who have always worked with anglophones to hire francophones. "At the Institut, we try to break the ice by publicizing our many talents. But for the time being at least, as in the hockey profession, only extremely gifted Québécois are actively sought outside Québec."

The École polytechnique's comprehensive nuclear engineering program stubbornly survives



**Joel Liederman, general manager of AECL's CANDU Operations in Montréal, discusses features in the CANDU 3 system design with Nicole Coadou.**

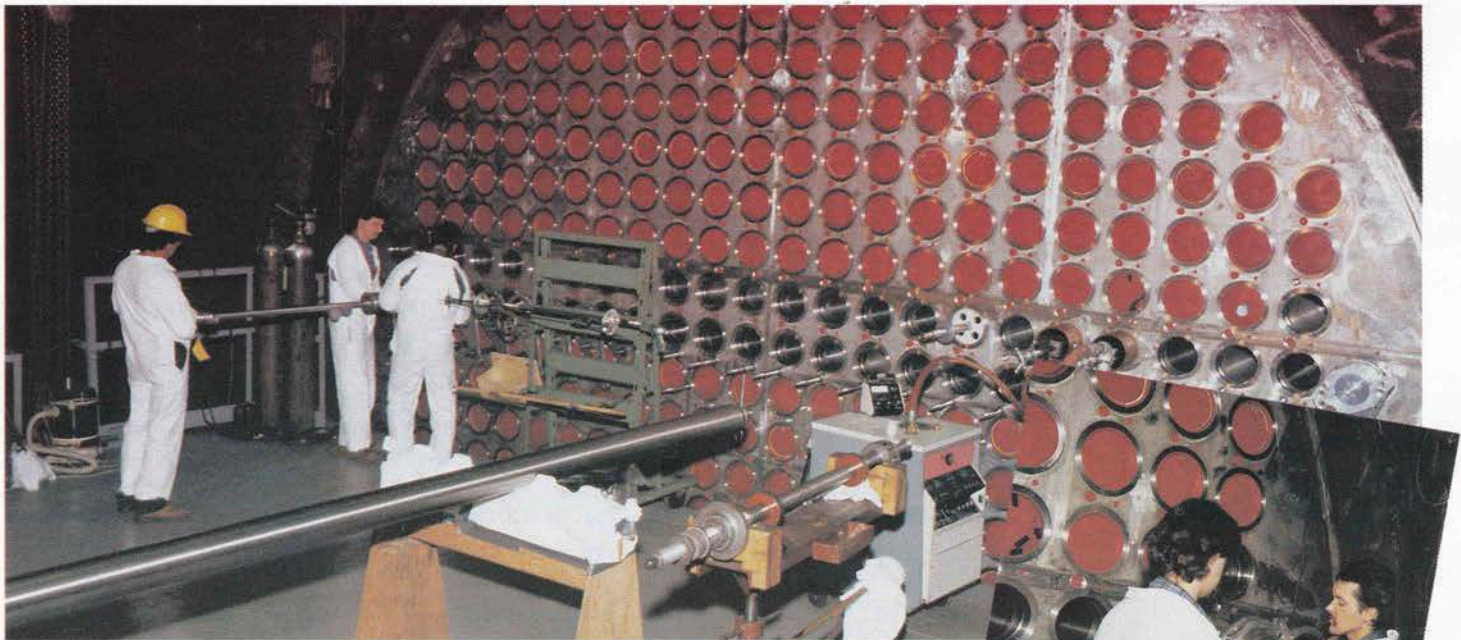
Québec. The nuclear industry in Québec not only has a past and present, they say, but a future.

"In the near future, the costs of nuclear power will undercut hydroelectricity," says Joel Liederman, general manager of AECL's CANDU Operations in Montréal.

Liederman believes that Montréal in

despite Hydro-Québec's low-key nuclear program. The only one of its kind in Québec, the program has graduated about 100 students since it began in 1970. But it has always been difficult to attract Québec students, due in large part to the province's relatively small job market for nuclear power engineers and technologists.





*(Above) The MIL Group manufactures calandrias used to contain fuel bundles and heavy water in CANDU reactors.*

*(Right) Workers insert fittings for the fuel channels in a massive stainless-steel calandria.*

Rozon is now aiming to attract students from Ontario to beef up the numbers in the program. "Most work related to nuclear power in Canada is done in Ontario (where nearly 50 percent of the province's power is supplied by nuclear generating plants)," he says. "Students from Ontario can study at our school in French and submit their written work in English. It's an attractive option for many young Ontarians who have a good grasp of the French language."

The Institut operates the only nuclear fission research reactor in Québec, a SLOWPOKE designed by AECL. The reactor has been used since 1976 for neutron activation analysis and for the production of radioactive medical tracers.

The school also uses a sophisticated thermalhydraulic laboratory of its own design to study thermal transfers. It is the only facility in any Canadian university that is comparable to the high-technology thermal loop located at AECL's Whiteshell Nuclear Research Establishment near Pinawa, Manitoba.

Another important activity at the school is a research program on reactor physics offered by the Groupe d'analyse nucléaire (GAN), which is chiefly funded by Hydro-Québec. This program involves mathematical and computer analysis of the movement of neutrons inside a reactor.

"Close ties with the Canadian nuclear industry guarantee the rapid transfer of technologies developed by GAN," says Rozon. "We want to increase these transfers, particularly with AECL. Québec nuclear researchers have something to offer the rest of the country, and we must get that message out."

The major source of employment for the school's nuclear engineering graduates is Hydro-Québec's Gentilly-2 power plant, located 30 kilometres east of Trois-Rivières at Bécancour on the south shore of the St. Lawrence River.

"Hydro-Québec grants and subsidies, currently in the neighborhood of \$225,000 annually, enable us to maintain the nuclear engineering program," says Rozon. "In turn, we train the nuclear engineers that Hydro-Québec needs to operate Gentilly. Many of the graduates become managers, which creates job openings for new graduates, and that's how the wheels keep turning. About half the graduates from our nuclear engineering program, in fact, have worked for Hydro-Québec."

## Nuclear island

A nuclear island in the province's sea of hydroelectric generating stations, Gentilly-2, a 685-megawatt CANDU power plant,

attests to Québec's nuclear expertise. In 1988, the plant production capacity was ranked 12th in a worldwide pool of 272 reactors rated at 500 megawatts or more. (Production capacity is the electricity actually generated by a plant expressed as a percentage of what is theoretically possible).

Although the station annually produces just four percent of Hydro-Québec's 24,590 megawatts of installed capacity, it nonetheless plays an important role in the utility's supply network.

"Our output to central Québec has an important stabilizing effect on the network, which receives most of its electricity from hydraulic stations located hundreds of kilometres away from the main centres of consumption," explains Roland Boucher, director of the Gentilly-2 station. "Our Bécancour site is ideally located for supplying the major markets of Montréal and Québec City."

Construction of Gentilly-2 began in November 1973, and the plant has operated commercially since October 1983. The



decision to build Gentilly-2 was made during a period of economic expansion and increasing energy demand. Despite the fact that Hydro-Québec had decided in 1972 to harness the rivers of the James Bay area in a massive hydroelectric project, the utility still believed that a major portion of its output would be generated by nuclear power plants by the end of the century. With the demand for electricity then increasing by six percent a year, that assumption seemed reasonable. However, with the economic recession of the early 1980s and the introduction of strict energy-conservation measures, the anticipated growth in demand failed to materialize. It is only in the last few years that the growth in demand has picked up again to former levels.

"When Gentilly-2 was put into operation, Hydro-Québec only required it to produce at 50 percent capacity, which indicates the abundance of electricity in Québec at the time," says Boucher. "Now, we are operating at maximum capacity, and our input to the network, especially because

of its stabilizing effect, is needed."

Although the Gentilly-2 site at Bécancour could accommodate four additional 685-megawatt stations, it is a fact that Hydro-Québec's current development plan calls for no new nuclear power plants. "Naturally, we would like to see other nuclear plants in Québec," admits Boucher. "But for the time being, hydro-electricity is more economical. When nuclear power becomes the more economical choice, Hydro-Québec's development plan could change. Meanwhile, the team we've trained at Gentilly-2 will be ready to take up the challenge if the need for additional nuclear plants arises."

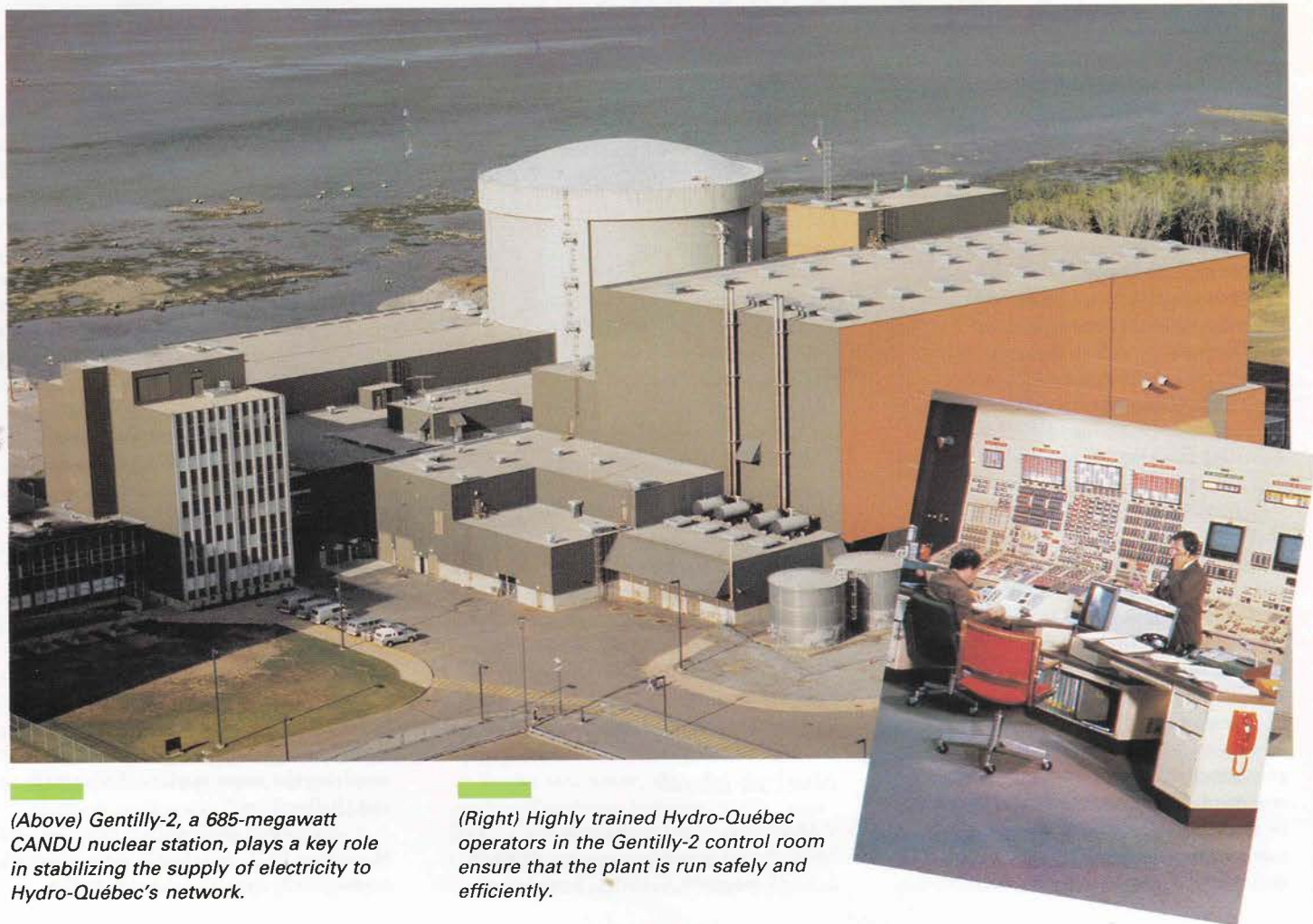
### Fiercely proud

A major portion of the engineering work for Gentilly-2 was carried out by AECL's CANDU Operations group in Montréal. "We are fiercely proud of our work at Gentilly-2," says Liederman, who was the director of engineering for AECL's work at

the station when it was being built.

Although CANDU Operations employs just 130 people in Montréal compared to 1,050 people in Mississauga, Liederman considers Montréal to be an integral part of the CANDU team. "Credit for a large measure of CANDU's success and international reputation is due to the people working in our Montréal offices," he says.

Following completion of the Gentilly-2 project and with no new nuclear plant construction on the horizon, the Montréal office set out to diversify its operations. The group now specializes in the decommissioning of nuclear power plants, an extremely complex operation. To date, the group has decommissioned AECL's Gentilly-1 experimental reactor in Québec, and Ontario Hydro reactors at Douglas Point and Rolphton. The experience gained through these jobs brought international recognition for the "static state" decommissioning technique developed by the Montréal team. In this technique, most equipment is not dismantled immediately.



(Above) Gentilly-2, a 685-megawatt CANDU nuclear station, plays a key role in stabilizing the supply of electricity to Hydro-Québec's network.

(Right) Highly trained Hydro-Québec operators in the Gentilly-2 control room ensure that the plant is run safely and efficiently.



Instead, dismantlement is delayed to allow time to perform the lion's share of the work of deactivating the components, before final decommissioning takes place.

The Montréal team has developed a number of other exportable technologies, among them, concrete containers for dry storage of irradiated fuel at nuclear plant sites.

"We will never again be dependent on a single project, such as working on the CANDU design," says Liederman. "Diversification enables us to adapt to every circumstance. During the current ebb in the nuclear power field, we have not only survived, we have prospered."

## Ready and waiting

Québec, with its legions of engineers and entrepreneurs, could very quickly respond to a call for new nuclear power plant construction. In the meantime, companies in the nuclear industry have survived very well by finding work outside Québec and Canada.

Canatom is an engineering consulting firm that specializes in the design, project management, and construction of nuclear power stations and heavy-water plants. This Montréal-based company has played an active role in building CANDU reactors in Québec, New Brunswick, Argentina, South Korea, and Romania, as well as the Tokamak fusion research reactor in Varennes, Québec. (See the article on fusion in this issue on page 13.)

In the absence of any current CANDU projects, Canatom has spent the past few years assessing costs and construction schedules for American nuclear power plants. "Our expertise is recognized, and the fact that we are a Canadian firm frees us from conflicts of interest that our American counterparts might face," explains René Godin, president of Canatom. A franco-phone originally from Saskatchewan, Godin has relocated 18 times during his career to play important roles on various construction projects, including the CANDU projects in Québec, New Brunswick, South Korea, and Romania.

Canatom is the nuclear arm of Lavalin, SNC, and Monenco (Montréal Engineering Company). There is a large exchange of staff with these companies, allowing the company to ride out any downturns in its nuclear business. "Because our organiza-

(Continued on page 11)

## THE CANADIAN IRRADIATION CENTRE IN LAVAL

by Éric Devlin

The Canadian Irradiation Centre (CIC) at the Institut Armand-Frappier in Laval, north of Montréal, is home to a unique combination of scientists who are linking research on food irradiation to work in virology, microbiology, immunology, and environmental sciences.

"The centre was established at the Institut Armand-Frappier because nowhere else in Canada, or in the world for that matter, could you find scientists in related fields of study so readily available to collaborate on irradiation projects," explains Raymond Charbonneau of the CIC. "Through this collaboration, we can apply to irradiation the scientific think-tank techniques that have been so successful for 50 years at the Institut."

The CIC was set up in 1987 at a cost of \$6.2 million. About half this amount represents the land, the building, and laboratories provided by the Institut Armand-Frappier. The other half of the cost was for the irradiator, provided by Atomic Energy of Canada Limited (AECL). The current budget for the centre is shared by the Québec government and Nordion International Inc., the successor to AECL's Radiochemical Company.

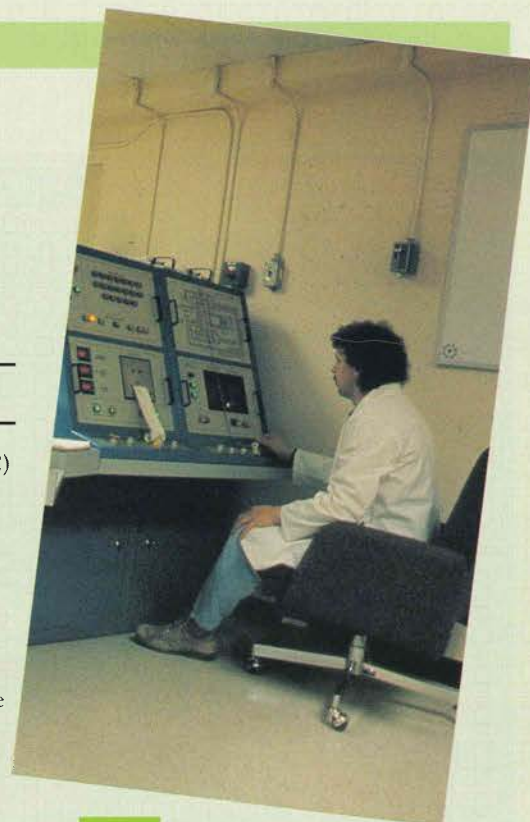
Establishment of the CIC is a tribute to the persistence of Marcel Gagnon, the current director of CIC and a driving force for food irradiation in Canada.

## Ironical situation

Although there are more than 140 irradiators in the world, 80 of them built by AECL, it is ironic that no food irradiators operate commercially in Canada, although there are three medical irradiators.

"There was one in the late 1950s in the Saint-Hilaire region near Montréal," recalls Gagnon. "A private developer even then understood the advantages of irradiation in preventing potatoes from germinating. But the project was not profitable."

This profitability criteria partially explains the lack of food irradiators in



*Jeannot Proulx monitors an irradiation process from a control room console at the Canadian Irradiation Centre.*

Canada. A recent study by Agriculture Canada confirmed that, in addition to problems related to consumer resistance, the financial rewards of the process are limited by the seasonal nature of our vegetable production.

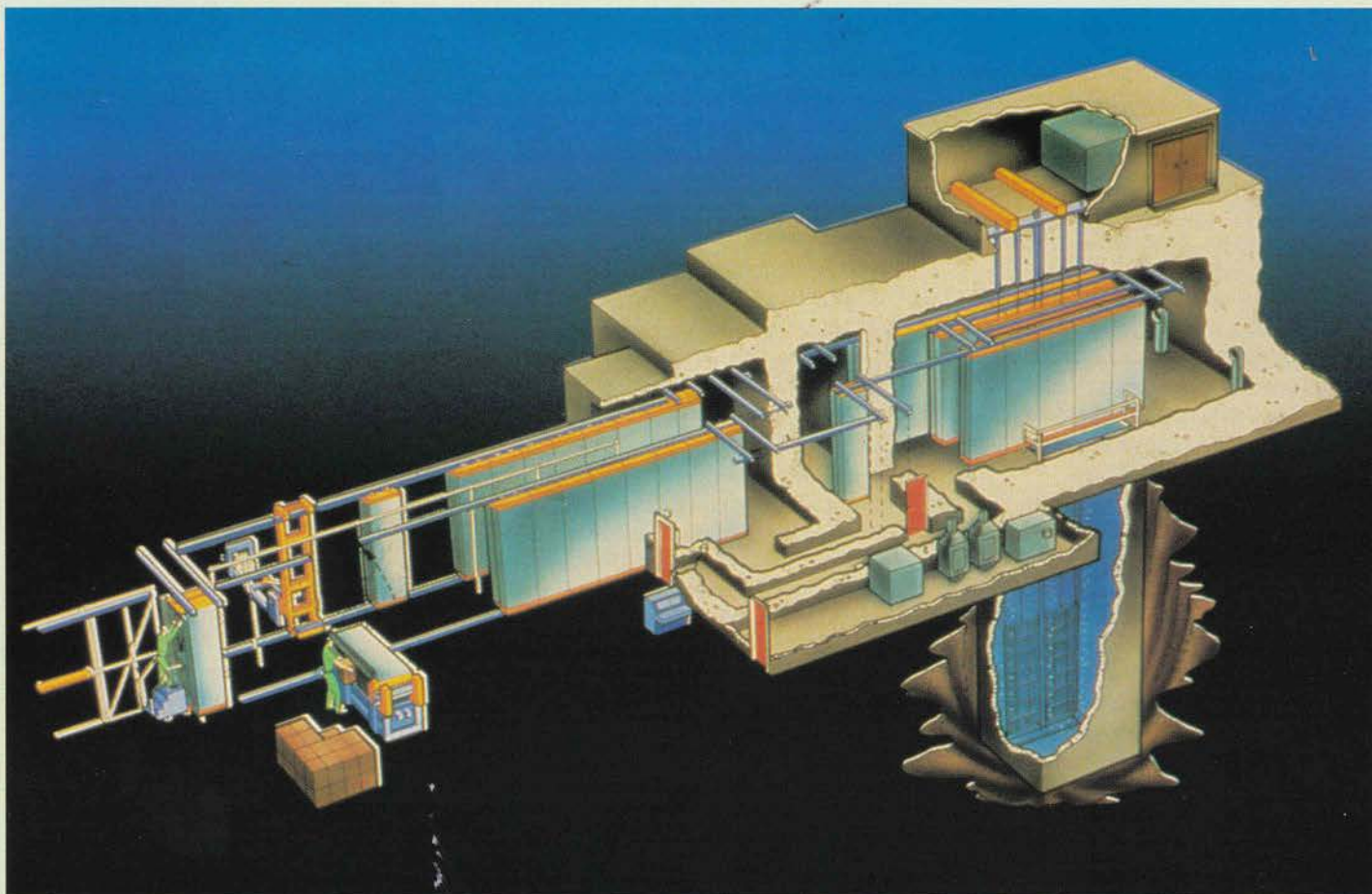
Yet Canadians will consume imported irradiated foods. "The marketing of irradiated food became inevitable in 1987 when the United States prohibited the spraying of fruits and vegetables with ethylene dibromide. This ban left American agriculture open to destructive fruit fly infestations," states Marcel Gagnon. Ethylene dibromide, used for more than 30 years, is now considered carcinogenic.

Irradiation consists of exposing food to an energy source — either gamma rays produced by Cobalt 60 or X-rays — to excite the peripheral electrons of the atoms in the food. The food material does not disintegrate because the core is unaffected.

Complex molecular structures, such as DNA and RNA, are more sensitive to radiation. Thus, radiation primarily affects growing tissue. That is why the first authorized application of radiation in the 1960s involved the germination of onions and potatoes. Later, the destruction of insect eggs and larvae present in grain and flour was authorized.

Apart from the prohibition of chemical





The Centre's carrier-type gamma irradiator uses an automatic conveyor to transfer products into the irradiation room and around the Cobalt 60 source. The concrete radiation shield is designed to meet international standards of radiation protection for personnel.

food preservatives, use of irradiation techniques has been spurred by the popularity of exotic fruit, which is fragile and expensive to ship. "Our work showed that by irradiating mangoes, we could extend the preservation time to three weeks from the usual 10 days," states Monique Lacroix, a professor at the Centre de recherche en sciences appliquées à l'alimentation (CRESALA).

### Earlier work

The CRESALA, established by the University of Québec in Montréal in 1972, operates at the Institut Armand-Frappier. Its presence, in fact, was instrumental in attracting the CIC to locate in Laval. About six postgraduate students from the CRESALA currently are research assistants at the CIC.

Raymond Charbonneau studied the effect of irradiation on ground beef for the

CRESALA. He observed that, with a certain dose of irradiation, ground beef can be kept in the refrigerator for up to four extra days. Irradiation also destroys the salmonella in ground beef. Each year in the United States, two million people suffer food poisoning caused by salmonella-type bacteria, and it is estimated that 80 people die of it. "Meat irradiation would make it possible to decrease the number of poisonings," states Charbonneau.

The success of laboratory experiments on irradiation over the past 30 years, however, has not calmed all public fears. "Obviously, the fear of anything nuclear has a negative effect on food irradiation," says Charbonneau.

"We favor the labeling of irradiated products," says Lacroix. "Marketing studies conducted in the United States and Africa have proven that consumers usually prefer irradiated products over non-irradiated ones because they are fresher." Irradiated

strawberries at 10°C, for example, retain their appearance for eight days instead of two. And some irradiated fish can be kept in the refrigerator for 10 days longer than non-irradiated fish.

### A difficult victory

Marcel Gagnon is growing impatient about the slow penetration of irradiated food on the Canadian market. He envies the 20 or so countries, including Holland, France, and Belgium, where approximately 40 food products are irradiated on an industrial basis.

His impatience is easily understandable. In 1957, he was asked to head the first research team funded under the Eisenhower Atoms for Peace Program. The team was investigating the use of gamma rays to replace blanching as a means of destroying enzymes prior to freezing or preserving vegetables. Blanching exposes vegetables to



wet heat to preserve their texture, taste, and appearance.

"Following our work, the U.S. Food and Drug Administration classified radiation as an additive," says Gagnon. "This step was taken to give the Americans time to produce Cobalt 60, the best source of gamma rays, at a lower cost than Canadians could."

In Canada, Cobalt 60 is a byproduct of the CANDU nuclear reactor operation. The United States, however, was never able to produce it at a lower cost, and Canada has maintained its status as the chief producer of Cobalt 60 to this day. Canada currently produces 85 percent of the world's supply.

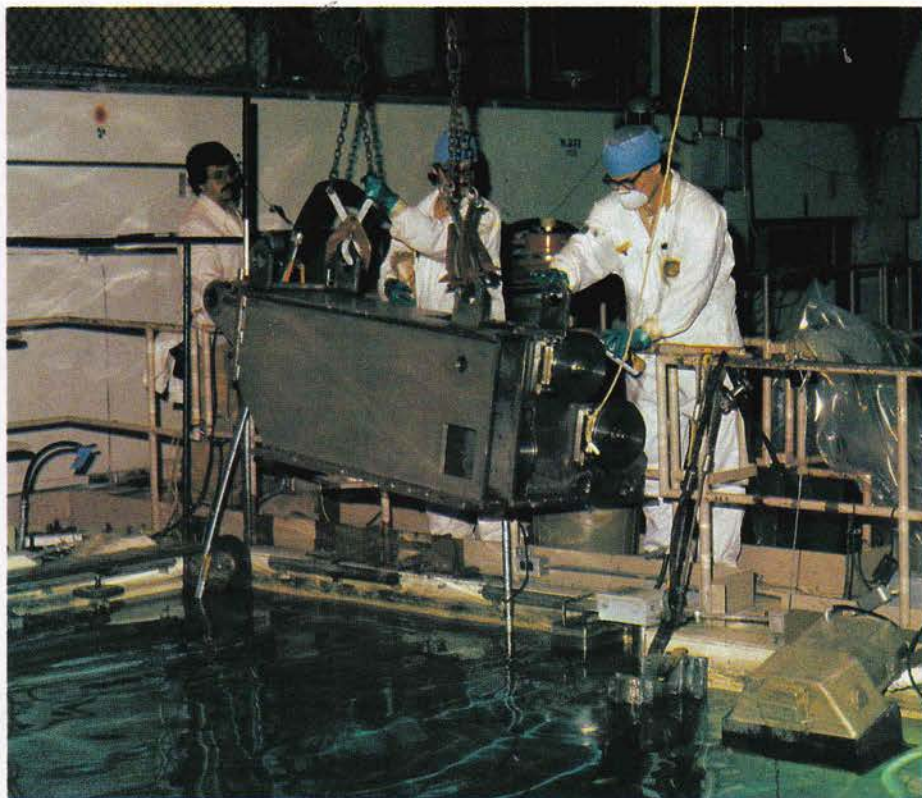
## Delayed introduction

"The Food and Drug Administration's decision to consider irradiation as an additive and not a processing technique delayed marketing for approximately 30 years," maintains Gagnon. "During all those years, almost half the crops produced in developing nations never reached the markets because of the lack of effective means of preservation. Food irradiation is a simple solution to ensure the food self-sufficiency of these countries."

Under the aegis of the International Atomic Energy Agency (IAEA), the Food and Agriculture Organization (FAO), and the World Health Organization (WHO), a vast research program was launched in the 1960s to answer questions raised by this preservation method. Naturally, levels were determined to establish how much radiation could be administered without altering the nutritive and olfactory characteristics of the food product. Another aim of this program was to check whether irradiation produced food toxins, a theory that was proven false after many years of research. Finally, in 1983, 130 countries adopted a general standard to cover food irradiation.

With the growing international interest in food irradiation, it became imperative for Canada to acquire a centre for the research, development, and demonstration of Canadian irradiation technology. Finally, in 1987, Marcel Gagnon's long-held dream came true with the establishment of the Canadian Irradiation Centre on the Institut Armand-Frappier campus. ■

*Éric Devlin is a Montréal-based science writer.*



*Specialists from AECL's Montréal CANDU Operations group performed decommissioning work at the Gentilly-1 plant.*

(From page 9)

tional structure is so flexible, we have been able to breeze through the present difficult times while we remain ready and able to take advantage of future nuclear contracts."

A disappointment for the firm was the cancellation of the nuclear submarine program in the recent federal budget. Canatom would have done the design work for the nuclear propulsion system. "It doesn't matter," says Godin, dismissing the setback, "the pendulum is swinging back in the direction of the nuclear option because it is the most environmentally safe technology available."

Godin says he hopes the turnaround doesn't take long, however. His only fear is that the current slump may have turned many young nuclear engineers and suppliers away from Québec. "We may have to make a mad dash to adjust to the new challenges," says Godin. "The day will come when 'old-timers' like me have to retire, and a new generation will have to take our place. I hope that the younger generation in Québec will be ready when the nuclear revival arrives. That's also why we at

Canatom want to increase our support for Québec universities that train the young people who will carry on the nuclear industry here."

Another major company involved in Québec's nuclear industry is MPB Technologies Inc., located in Dorval. Founded in 1976, the company specializes in high-technology products and R&D in such diverse fields as lasers, telecommunications, microwaves, space technology, digital graphics, and fusion research.

As a member of the consortium for the Tokamak de Varennes fusion reactor program, MPB Technologies designed and implemented many of the subsystems for the project. The company developed several of the diagnostics used to measure the results of plasma experiments in the reactor, including laser and microwave systems, magnetic loops, and an impurity injection system. It also put in place a network control system that manages the data from experiments and monitors the status of the machine subsystems for proper operation.

In addition to its work in Québec, the company is providing designs and hardware



for international fusion programs. The company has collaborated in the past with the Institute of Plasma Physics in Julich, West Germany, and is now working with the Istituto Gas Ionizzati, Italy, and with MIL and the Los Alamos National Lab in the United States to test and sell MPB's encoder and decoder modules.

MBP currently employs about 150 specialists, including physicists, engineers, and technologists, at its 10,000-square-foot headquarters in Dorval and at Pointe Claire, outside Montréal. "The international recognition of our expertise is growing and so are the spin-offs from the fusion program which have produced products and systems of interest to foreign countries," says Issie Shkarofsky, MPB's director of fusion technology. "We will remain in a good position if fusion research continues to expand."

Another company that would benefit from a nuclear revival in Québec is the MIL Group, which manufactures calandrias, the huge stainless steel hearts of CANDU reactors. Calandrias contain the fuel bundles and heavy-water moderator used in the CANDU fission process.

### *The international recognition of our expertise is growing*

MIL's most recent calandria, manufactured in August 1988, was built for Ontario Hydro's new CANDU power plant now under construction in Darlington, near Toronto.

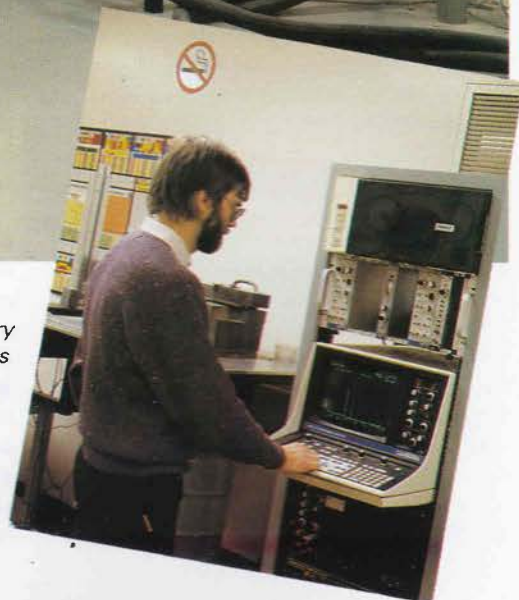
The MIL Group recently announced the closure of its calandria-producing plant in Montréal. Nevertheless, the company has retained key personnel and says it is ready to build calandrias at its plants in Tracy or Lauzon, or even at a plant that it could build elsewhere in Québec.

Inevitably, Québec will come to realize the benefits of promoting nuclear power, says Daniel Rozon. "Because nuclear power plants don't contribute to acid rain or the greenhouse effect, they have important advantages for the environment. And the small volume of nuclear wastes minimizes the problem of their final disposal. The impact of geological disposal sites, in my view, is negligible when compared to the impact of hydroelectric projects flooding thousands of squares kilometres of land that can never be returned to its original state." ■



(Above) The thermalhydraulics laboratory at the École polytechnique de Montréal is used to study thermal transfers, such as those in nuclear reactor fuel assemblies.

(Right) Research associate Jean Saint-Pierre carries out neutron activation analysis at the École polytechnique.







# A CAGE FOR THE SUN

*Fusion holds the promise of an inexhaustible energy supply for mankind, but the technical challenges and costs are formidable.*

by Ron Thomas

Developing a fusion reactor has been likened to building a cage for the sun. Indeed the technical challenges of harnessing here on Earth the same energy source that powers the sun are formidable. And the costs of achieving commercially viable fusion energy are daunting. The first engineering test reactor will likely carry a price tag of \$5 billion. Even now, each of the four main players — the European Economic Community, the United States, Japan, and the Soviet Union — are investing about \$500 million a year in their quest for the fusion fire.

To solve the fusion puzzle, scientists are working with an exotic substance called plasma at millions of degrees temperature. Often referred to as the fourth state of matter, plasma is a swirling cloud of completely ionized gas that makes up most of the matter of stars but exists on Earth for only short periods of time in such places as lightning discharges. An alternative concept being explored by scientists uses ultra high power laser beams to ignite the fusion reaction.

Nevertheless, the dream of developing a workable and economic fusion reactor, with its promise of a virtually limitless source of non-polluting power for an energy-hungry world, remains. If successful — and it is by no means clear that it will be — a single glass of water, from which fusion fuel can be extracted, would be able to produce the energy equivalent of 600,000 litres of gasoline.

On a global scale, Canada's \$20 million fusion program is small. But the country hopes to parlay its expertise in certain specialized niche areas — tritium technology, remote-handling robotics, and high-power electrotechnology — into a piece of the action.

"Our goal is to gain access to the fusion programs of other countries, to ensure that we have the trained people and the experience to take advantage of fusion power when it proves viable, and to develop business opportunities for Canadian industry in these niche areas," says David

funding and coordinates programs for most of the country's fusion work, in cooperation with provincial governments, power utilities, industry, universities, and centres of science and technology. AECL manages federal participation in the program.

The NFP participates in two major projects: Centre Canadien de Fusion Magnétique (Tokamak de Varennes), a plasma physics research installation operated by Hydro-Québec; and the Canadian Fusion Fuels Technology Project (CFFTP), a joint project with Ontario Hydro and the Ontario government to

develop technologies and business opportunities for the processing and handling of fusion fuels, robotics, and engineering services and equipment.

The other main component of the NFP is an active international program, involving bilateral agreements with Europe, the U.S., and Japan; the posting of personnel in fusion projects in these countries; and membership on world organizations that have fusion interests, such as the International Energy Agency and the International Atomic Energy Agency.

Access to these international programs is important if Canada is to build a fusion reactor in the future, says Bill Holtslander, manager of NFP's international program. "We want to make sure that our scientists and engineers

don't have to start from a dead stop and that we have access to the latest information. We also want to be in a position to obtain some of the contract work that's available. At the same time, we don't want to be seen as parasites on the world program — we feel that we can make a valuable



*Members of Canada's National Fusion Program headquartered at AECL's Chalk River laboratories, left to right, Gil Phillips, Bill Holtslander, Charles Daughney, Carolyn Jonckheere, and David Jackson.*

Jackson, director of the National Fusion Program (NFP), headquartered at Atomic Energy of Canada Limited's (AECL's) Chalk River Nuclear Laboratories.

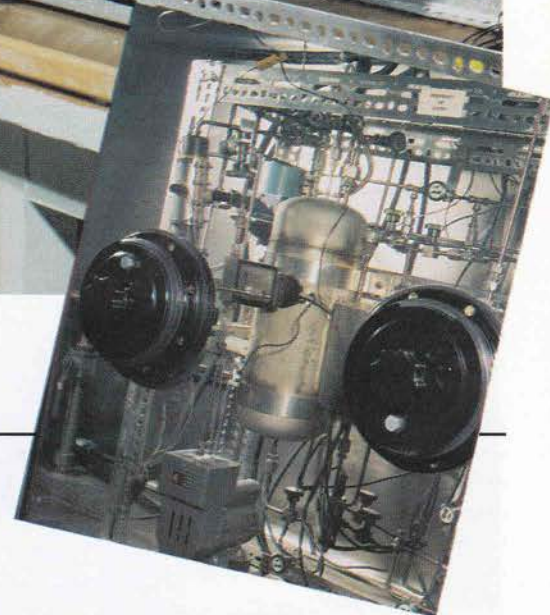
The NFP, established in 1978, is Canada's central funding and policy agency for fusion development. It provides core





(Above) Frank Gravelle, a technician at AECL's Chalk River laboratories, tests a small-scale fusion fuel clean-up system.

(Right) A close-up view of the experimental fusion fuel clean-up system.



contribution in specific areas."

All this international activity is aimed at making the long-elusive fusion dream a reality. Fusion, like fission, is a nuclear process. But in fusion, the nuclei of atoms are fused together; in fission, they are split apart.

What is common in both nuclear reactions, however, is that there is less mass than before. The missing mass is converted to energy in accordance with Einstein's famous equation  $E=mc^2$  (Energy equals mass times the square of the velocity of light). Because the velocity of light is equal to 300,000 kilometres per second, a small amount of mass lost in the fusion or fission process can produce an enormous amount of energy.

While mankind has mastered the fission process, nuclear fusion presents a more difficult problem: How to fuse nuclei when they both carry positive electrical charges and repel one another. Two conditions assist the process — sufficient confinement that is long enough to allow fusion to occur, and high temperatures that will drive the nuclei at such high speeds that some will

collide. The sun, with its tremendous size, relies upon gravitational confinement — a method that seems impossible to duplicate on Earth.

One solution being explored is inertial confinement systems, which use various kinds of high-energy beams, such as lasers and particle beams. In these systems, intense laser beams are directed simultaneously onto a pea-sized spherical fuel pellet from all sides. The blast of light energy vaporizes the fuel pellet container, which is made of glass or plastic, and the resulting shock wave compresses the fuel to a very high density to trigger a fusion reaction.

The second method being investigated — and the one believed to have the earliest chance for success — is magnetic confinement, where the aim is to ignite the fusion reaction through high temperatures. Here, a window is open because researchers can use the heavier hydrogen isotopes, deuterium and tritium, which require an ignition temperature of about 100 million degrees.

Such temperatures are achievable in plasma, but the problem remains of how to contain superheated matter that would melt

ordinary materials. In fact, the major problem is that container materials coming in contact with the plasma would instantly cool the plasma and extinguish the fusion reaction.

The proposed solution is not to use a material container at all, but to trap the plasma within a magnetic field — a feat that has been compared to trying to wrap jelly in rubber bands.

## Magnetic confinement

Experiments with magnetic confinement are currently being carried out in Tokamak machines at several locations around the world, including Tokamak de Varennes in Québec and the University of Saskatchewan where a small research Tokamak operates. Tokamak machines were first built in the Soviet Union, and the word Tokamak is an amalgam of the Russian



words for torus (meaning doughnut-shaped), chamber, and magnetic.

In these machines, coils wound around the torus create the magnetic field to contain the plasma. The plasma current is driven by an external power source supplied by transformers, neutral particle beams, or radio frequency waves. The current flowing through the plasma generates the heat required to start the fusion reaction.

The goal is to trap the plasma in a magnetic field for a sufficiently long time to allow the temperature and density of the plasma to build up so that fusion can take place. To date, scientists have been able to hold plasma for only one to three seconds, far too short for a commercial reactor.

Canada's magnetic confinement research program is centred at Centre Canadien de Fusion Magnétique's Tokamak de Varennes facility, located near Montréal at Hydro-Québec's Institut de recherche en électricité du Québec. Constructed at a cost of about \$50 million, the facility became operational in March 1987. The program is funded 50 percent by the federal government, and 50 percent by Hydro-Québec and the Institut national de recherche scientifique of the University of Québec.

The first phase of the project, involving the commissioning of the machine and its diagnostics, is now complete. "The machine met or exceeded all its design parameters," reports Charles Daughney, manager of NFP's magnetic confinement program. "And more than 20 diagnostic systems are up and working."

The diagnostics are particularly important for carrying out experiments. "We need rather sophisticated techniques to measure or monitor what is happening inside the torus," explains Daughney. "There are two types of diagnostics, ones which might be called passive that observe X-rays and the like generated by the plasma, and others which might be called active that shine laser or particle beams into the plasma to see what it does to them." The observations are used to study plasma and its interactions with various materials in the fusion process.

Like other Canadian projects, Tokamak de Varennes is concentrating on specialized niches, in this case, long-pulse operation and plasma wall interaction studies.

Even the largest fusion experiments now are able to operate in pulses of only a few seconds, then they must be shut down for  
(Continued on page 16)



## AECL'S FUSION BLANKET TECHNOLOGY

Scientists at Atomic Energy of Canada Limited's (AECL's) Chalk River laboratory are in the vanguard of worldwide research into fusion breeder blankets, a key component of future fusion reactors.

The blankets, by absorbing neutrons released in the fusion process, provide a protective shield against radioactivity, produce tritium for use as fuel, and capture heat for the generation of electricity. The fusion blanket, made up of several hundred tons of lithium ceramics or lithium in solution, would surround the plasma in the reactor.

The Chalk River fusion blanket project is a joint effort of the Canadian Fusion Fuels Technology Project, which provides 75 percent of the funding, and AECL, which provides 25 percent.

Ian Hastings, manager of the Fuel Materials Branch at Chalk River, says that

AECL technologist Stan Bokwa uses the glove box in the tritium analysis control room to monitor tritium recovery tests.

they are pushing a spherepac technology, in which uniform lithium ceramic spheres about one millimetre in diameter would fill the blanket.

The lithium ceramics in the blanket, in fact, could be monolithic (a solid block), pellets, or spheres. "The concept that will be accepted is still up for grabs, but we believe we have a winner with our spherepac technology," says Hastings.

The small size of the spheres provides the edge. The tubular-shaped pellets, by contrast, are 10 to 15 times larger. "The spheres are less susceptible to temperature differentials that can build up between the core and the surface of the lithium compound," explains Hastings. "There is less chance that they will crack and break up into smaller pieces or into a powder." The spheres would provide a more stable bed to maintain constant heat transfer



properties throughout the life of the blanket, and they also would be easier to load and unload from the blanket.

Although the Chalk River lab already has fabrication techniques gained from experience with uranium dioxide (another ceramic) in the fission program, new methods must be developed for higher-speed production of the spheres.

"When you consider that there may be three hundred thousand million of these spheres in a blanket, then ways must be found to speed up the process of manufacturing them," says Brad Palmer, project

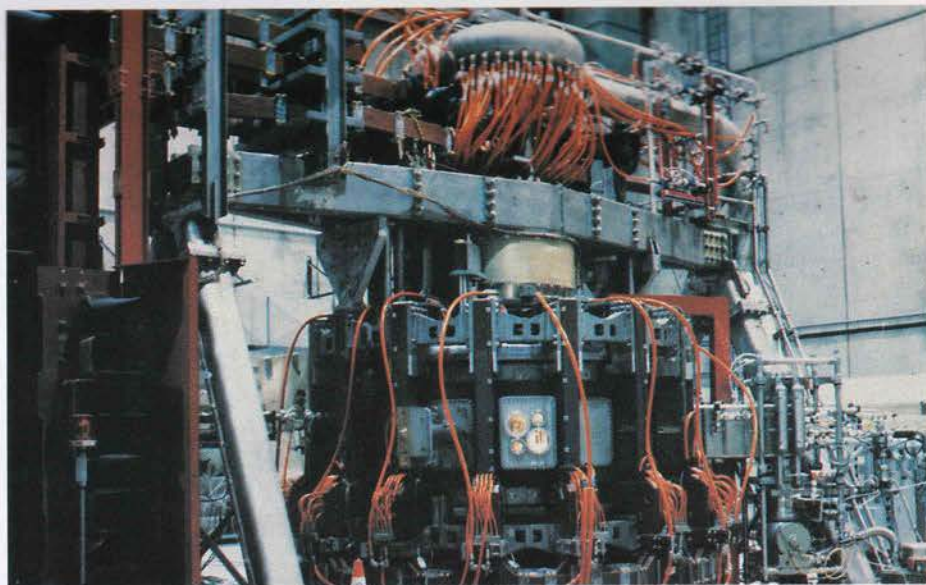


*Left to right, Ian Hastings, Leon Bourque, and Richard Verrall watch a small-scale fusion blanket simulation test being inserted into research reactor.*

leader of the fabrication development program. "We can't afford to wait around while they are being made."

The spheres could be fabricated from a number of different lithium compounds, but the Chalk River group is investigating lithium zirconate, a promising new candidate for use in the spherepac. To prove the spherepac technology, the group is making use of Chalk River's irradiation test facilities and tritium analysis lab to evaluate the lithium ceramic compounds.

"We have the spherepac concept, we are developing the high-speed fabrication techniques to back it up, and we have the reactor facilities to test it," says Hastings. "I think we're well along the way to our international goal of having spherepac blanket technology accepted as a viable concept." ■



*The Tokamak de Varennes fusion research reactor in Québec is the centre for Canada's magnetic confinement research program.*

(From page 15)

several minutes before starting up again. This short burst of activity, of course, would not be sufficient for a fusion reactor that must run continuously.

Early next year, scientists at Tokamak de Varennes will take the first step, by attempting a multi-pulse operation of about 10 one-second-on, one-second-off pulses. The eventual goal of the project is to operate a continuous 30-second pulse.

Scientists also will begin plasma wall interaction studies under long-pulse conditions. "We have to know how to handle the interface between the edge of the plasma and material in the first walls of the torus," says Daughney. "Otherwise, the wall material would be eroded away, and material coming in contact with the plasma would cool the plasma and shut down the fusion reaction."

## Fusion fuels

The first generation of fusion reactors is expected to be fueled by a deuterium-tritium mix, which can be ignited at temperatures of about 100 million degrees Kelvin. Second-generation reactors will likely be fueled by deuterium alone when the technology exists to reliably produce temperatures in the 500-800 million degree Kelvin range.

One of the advantages of fusion power is that both tritium and deuterium will be in

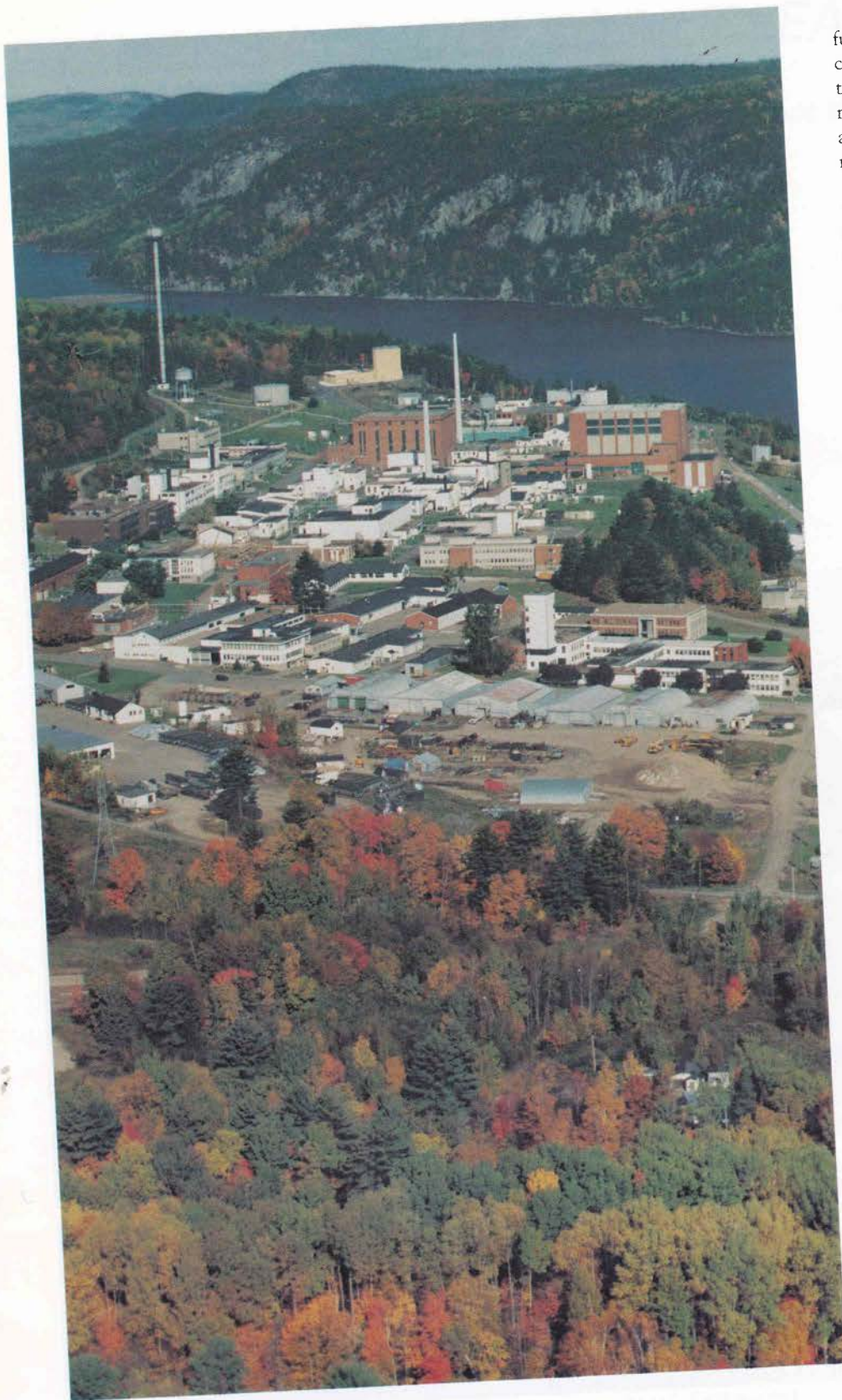
abundant supply. Tritium can be manufactured from lithium, which is available around the world in various mineral forms. The lithium can be converted to tritium in breeder blankets that will surround the fusion reactor. It is estimated there is enough lithium on Earth for up to 10,000 years of fuel production.

Tritium, in fact, is currently produced as a byproduct of the CANDU fission process. Ontario Hydro and AECL have developed methods of extracting and handling the tritium that have made Canada the major supplier of tritium in the world.

Development of true deuterium fusion, however, would usher in an era of inexhaustible energy for our descendants. Deuterium can be produced from ordinary water as heavy water ( $D_2O$ ). Ontario Hydro, for example, annually extracts hundreds of tonnes of  $D_2O$  from Lake Huron to use in its CANDU nuclear generating plants. Extractable deuterium in oceans and lakes could probably supply our energy needs for at least 100,000 years.

The Canada Fusion Fuels Technology Project (CFFTP) was launched in 1982 and is funded equally by the federal government, Ontario government, and Ontario Hydro, each currently contributing about \$2.2 million a year. While CFFTP manages the program, individual projects are contracted out to industry, universities, and provincial and federal agencies, such as AECL, usually on a co-funded basis.





AECL's Chalk River Nuclear Laboratories conducts a major portion of the tritium-related research for the fusion program. Tritium can be used as a fuel for fusion reactors.

CFFTP is concentrating its efforts on further development of existing Canadian capabilities in five of six major fusion technologies: tritium, breeder blankets, materials, remote equipment operations, and safety and environment. CFFTP is not now active in magnet technologies.

Canada's tritium program, for example, is perhaps the world's most advanced and is based on extensive technology developed for the removal of tritium from heavy water irradiated in the CANDU system. It is estimated that of the \$20 billion of capital value of the CANDU system in Ontario, about \$2 billion was invested by Ontario Hydro and AECL in developing tritium technology.

AECL's Chalk River site is one of the major participants in the CFFTP's tritium-related research program. Relevant work includes:

- the design, development, and testing of a breeder blanket for use in fusion reactors (see box);
- studies of the biological effects of tritium and of the means for monitoring tritium; and
- the development and testing of components for air detritiation and cleanup systems used in the event of a release.

Major facilities at the Chalk River site include a tritium extraction plant, a high-level tritium laboratory, a high-flux research reactor, and a ceramics fabrication unit.

Another area of Canadian expertise important to the international fusion community is remote-handling techniques, gained in the development of various CANDU refueling systems and in the development of the "Canadarm" payload manipulator by Spar Aerospace for the U.S. space shuttle program.

"When a fusion reactor is running, there will be lots of neutrons flying around which will cause metal in the machines to become radioactive. Although the neutrons will not generate heavy element wastes like fission reactors, the structures themselves will become radioactive with operation," explains Gil Phillips, manager of NFP's fusion fuels program. "The internal environment will be inhospitable to humans for servicing the machines, so a great deal of effort is going into designing machines that can be maintained by robotics."

Another key goal of the CFFTP program is to build Canadian expertise and establish



links with global fusion programs. Currently, some 15 Canadian scientists and engineers are on placements with major projects such as the Joint European Torus project in England.

According to most researchers, the path to fusion power will likely be marked by three milestones — energy breakeven, when we get as much energy out as we put into the plasma; ignition, when the total energy input into the plasma is generated by the fusion process itself; and commercial power production, when fusion plants begin generating large amounts of electricity.

Scientists estimate that we are approaching the first milestone, and the fusion community is now considering designs for engineering test reactors. The four fusion superpowers — the European Economic Community (EEC), the United States, Japan, and the Soviet Union — have agreed to jointly develop a prototype fusion power plant. The International Thermonuclear Experimental Reactor project, if built in the next decade, could cost \$5 billion. Canada is contributing to the program through the EEC fusion program, and there is a long-shot possibility that the plant could be located here.

## Cold fusion

The focus of international fusion work continues to be directed at the so-called hot fusion process. Jackson says that he does not hold out much hope for the success of the cold fusion process claimed by Stanley Pons of the University of Utah and Martin Fleischmann of the University of Southampton. AECL, like other national labs around the world, has failed to confirm the claims that a fusion reaction occurred at room temperature between deuterium nuclei in palladium electrodes suspended in heavy water.

"Unless we can discover what's behind the process, we can't say much about it," says Jackson. "Even based on the results claimed by Pons and Fleischmann, however, all they're producing is a low-grade source of hot water. In terms of thermodynamics, it would be difficult to extract useful energy out of it."

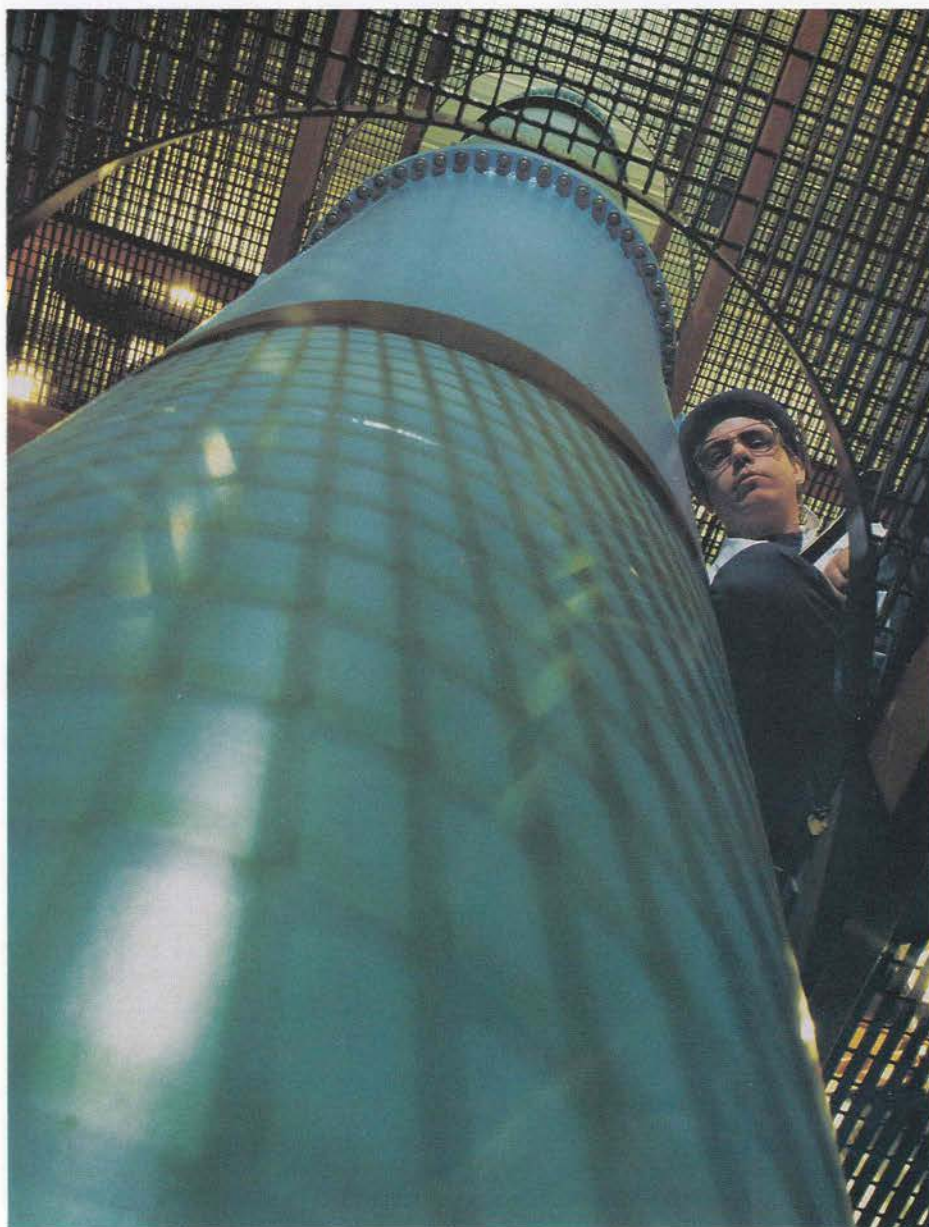
Jackson adds that he is not about to close the door on any potential source of fusion power. "At the present time, cold fusion seems improbable. There could be some effect there, but we would have to understand what was causing it before we

would be able to do anything with it."

Meanwhile, Jackson says that three scenarios can be envisioned for hot fusion. "The first two are perhaps most obvious — fusion reactors will be developed as standalone producers of electrical power, or they'll be too expensive or difficult to build to be able to compete with fission reactors. The third possibility is that fusion and fission may exist together in a symbiotic way. For example, fusion machines could be used to produce enriched fuels for advanced fuel cycles in fission reactors, thereby extending the utilization of uranium several

centuries into the future. Such fusion applications could be achievable because the requirements for producing enriched fuel are less stringent than those for producing large amounts of power," he says.

"I believe fission and fusion will coexist. Because of the economics, we're not going to say now that we've got fusion power, let's dump fission. At the same time, if we find that we can't build a commercial fusion reactor, we're not going to say let's forget fusion. With fusion, there are so many R&D paths we can follow, that if one doesn't work we'll probably go on to try another." ■



AECL's Steve Kenny checks installation of equipment at the Chalk River tritium plant.





## FRANCE SAYS 'OUI' TO NUCLEAR POWER

*Public support and home-grown technology make France the top-ranked nuclear power producer in the world.*

**M**ore than 70 percent of the electricity produced in France is generated by nuclear reactors, making France the top-ranked nuclear power producer in the world. France now has 53 operating reactors that annually supply 44,000 megawatts of electricity. Soon, nuclear power production in France will reach 57,000 megawatts.

François Bujon de l'Estang, France's ambassador to Canada, believes that the keys to the resounding success of the French nuclear industry are consensus and continuity: political consensus on the importance of maximizing the country's energy self-sufficiency; and technological continuity achieved through the standardization of nuclear reactor design.

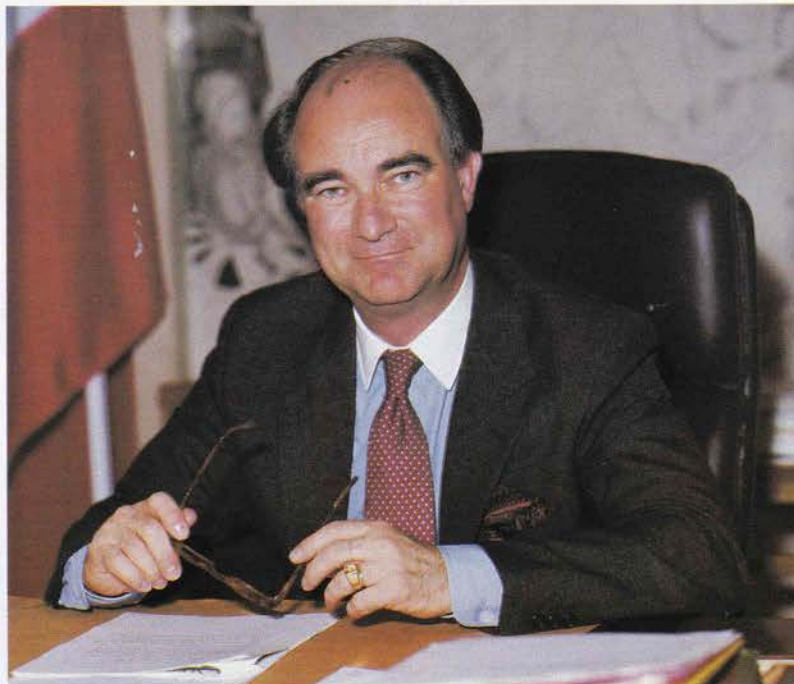
Having successively acted as international affairs advisor to the French Minister of Energy, director of international relations at France's Commissariat à l'énergie atomique, and as president of Cogema Inc. in Washington, D. C., the chief of French nuclear operations in the United States, Bujon de l'Estang is a prominent figure in the nuclear power industry. Appointed French ambassador to Canada last January 31, he met recently with *Ascent's* Benoit Legault for an interview at the stately French Embassy on Sussex Drive in Ottawa.

**Ascent:** Could you give us some background on the outstanding success of nuclear power in France?

**Bujon de l'Estang:** Before the Second World War, French nuclear research was already quite advanced. The Commissariat à l'énergie atomique was established in 1945 as soon as the country was liberated, and by the late 1950s, large nuclear companies were created.

The Commissariat's first major program was of a military nature, the atomic bomb

project that first got under way in 1957. I mention these military origins because they partially explain the success of civilian nuclear power in France. The French learned to take pride in an exclusively national nuclear program that involved no technology transfer from the Americans. We should always bear in mind that the American government agreed to share nuclear secrets with Great Britain immediately after the Second World War, but always refused to share such information with France, which therefore had to develop its military program alone.



*François Bujon de l'Estang, France's ambassador to Canada, says that his country's large-scale nuclear program is vital to energy self-sufficiency.*

Although the atomic bomb project was criticized by certain factions of the population early in the 1960s, ordinary French citizens nevertheless were proud of French technological achievements in the program. It was through these military applications that the French were initiated to nuclear power.

Next came the oil crisis of the 1970s,

which revealed France's vulnerability in energy resources. France, however, was the only Western European nation with significant uranium reserves. It was only logical that our nation turned to nuclear power, particularly in light of the fact that our civilian industry had already acquired considerable nuclear expertise.

For all of these reasons, then, public opinion was very receptive to the idea of adopting nuclear power as part of a vital energy self-sufficiency strategy. To implement this strategy, the government launched a large-scale nuclear power program in 1975.

We must remember that France is a centralized nation. It has a single electric company, Électricité de France (EdF), a single nuclear power plant manufacturer, Framatome, and a standardized design for French reactors. By comparison, the United States has 40 companies that produce nuclear electricity, five companies that manufacture reactors, and no standardized design, which means that it is always starting over from square one. EdF has ordered only light-water reactors from Framatome with an output of 900 to 1,300 megawatts. The standard design of the French reactors was a major factor in the program's success.

**Ascent:** Do all of France's major political parties agree on the need for nuclear power?

**Bujon de l'Estang:** All presidents and all successive French governments have publicly supported nuclear power. Of the four major French political parties, three openly stated their support for the nuclear power program in 1975 when the decision was made. Only the Socialist Party was divided. It was not against the program,



merely divided. When the Socialist Party took power in 1981, however, it reviewed the nuclear program, and after a few relatively minor changes, they approved it. Support for the nuclear power program has been continuous, and that support today still remains strong among the public, government, and scientific community.

**Ascent:** Have any accidents occurred in the history of nuclear power in France?

**Bujon de l'Etang:** There have been no major accidents in French nuclear power plants, and no substantial leaks of radioactivity into the atmosphere.

**Ascent:** What solutions have the French devised to handle nuclear fuel waste?

**Bujon de l'Etang:** France has chosen to reprocess used fuel, which allows uranium to be recycled through a chemical process. Fission products are vitrified based on a procedure used successfully in France for the past 15 years in a pilot facility, the vitrification workshop in Marcoule. An industrial-level application of this procedure is currently being developed in the reprocessing plant in La Hague. Through this method, it is possible to maximize the use of uranium and to reduce the volume of highly radioactive wastes. The wastes will then be buried in particularly stable rock formations, such as granitic and basaltic rocks, schists, or salt domes.

We have reached the site selection stage for the permanent disposal, in a few years, of highly radioactive wastes. Some sites have already been selected and are currently being reviewed and widely discussed. One site will be chosen for an underground laboratory which may become, once all requirements have been filled, our choice for a permanent site. As in other countries, environmentalists and local anti-nuclear groups have voiced their concern. We must take their views into consideration, and that is why discussions are taking place.

It is interesting to note the different attitudes in different towns on the nuclear option. This difference is sometimes in inverse proportion to the distance that separates a municipality from a nuclear facility. Some towns are completely opposed to nuclear development; others are very much in favor because of the economic benefits of such development. According to surveys, inhabitants of municipalities located close to a nuclear plant are among the stronger supporters of the nuclear option. These inhabitants have become used to the nuclear idea and the presence of

a nuclear plant has in a way demystified nuclear energy.

**Ascent:** Is there a ceiling on nuclear power growth in France?

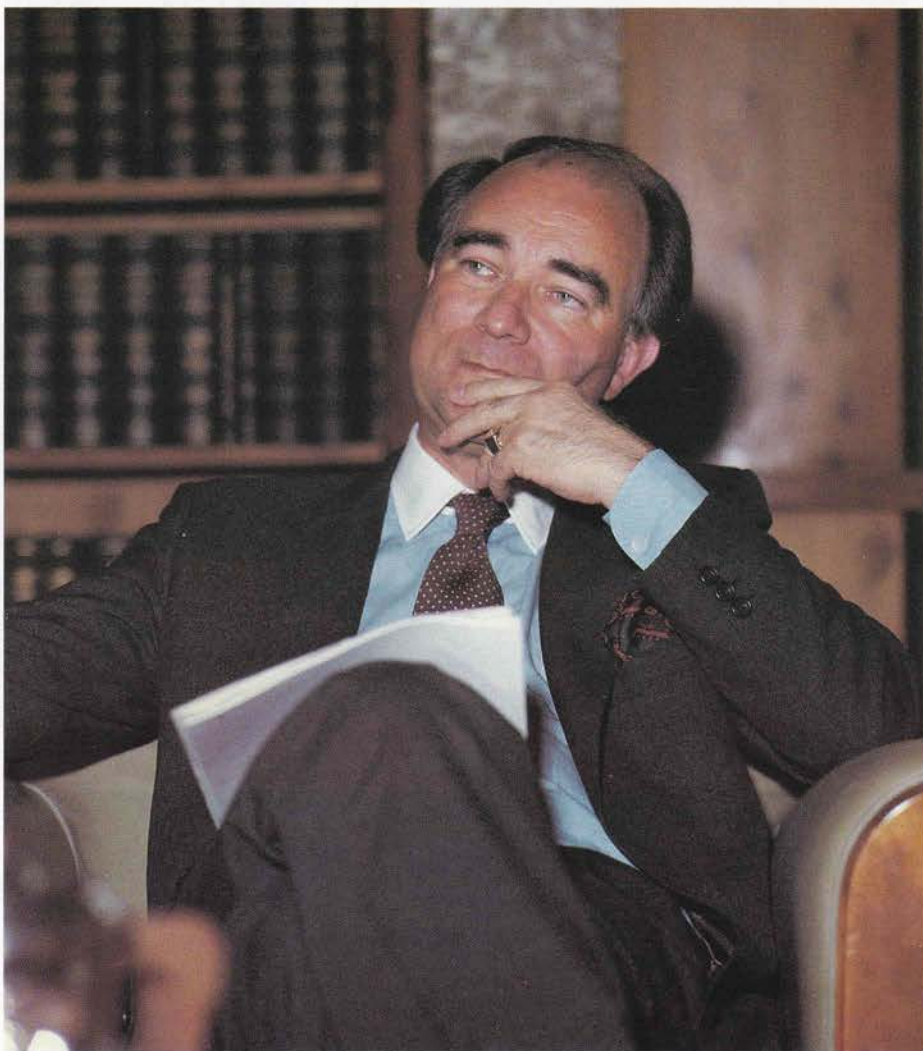
**Bujon de l'Etang:** Yes, by the mid-1990s France hopes to stabilize its production at approximately 75 percent of total electrical production. We want to diversify our energy sources to provide the electrical supply network with flexibility. We must not put all our eggs in one basket.

We realize, of course, that this flexibility comes at a price. Nuclear-generated electricity is half the cost of thermally generated electricity in France. A nuclear kilowatt-hour costs 0.2 francs, while a thermal kilowatt-hour costs 0.4 francs to produce. And by 1995, the nuclear kilowatt-hour is expected to cost three

times less than a thermal kilowatt-hour.

**Ascent:** The French nuclear power industry is often criticized for being secretive. Is this criticism justified?

**Bujon de l'Etang:** That criticism is often heard from anti-nuclear activists. They always claim that there is not enough openness or information available to them. Personally, I think these accusations are made in bad faith. The story is always the same: people in the nuclear industry are accused of not providing enough information, yet when information is made available, these same critics either don't want it or don't want to listen. Few industries have provided more public information. In my opinion, to say that there is not enough openness in the nuclear industry is an unfair accusation. ■



*Successive French governments have supported the nuclear power program which now provides 70 percent of the country's electricity, says François Bujon de l'Etang.*





## AGAINST ALL ODDS: WOMEN IN THE NUCLEAR INDUSTRY

*Women scientists and engineers are carving out successful careers at Atomic Energy of Canada Limited.*

by Rhonda Birenbaum

Madame Marie Curie, in 1898, coined the term "radioactivity" after she noticed that uranium spontaneously emitted rays. These rays, she wrote, contained energy enough to darken photographic emulsion through several thicknesses of paper. And from further study, she deduced that the radiation energy originated in the atom.

Four decades later, building on her mother's discoveries, Irene Joliot-Curie was among those who demonstrated nuclear fission. Together with her husband Frederic, she recorded the principles of nuclear reactors: nuclear reactions occur in explosive chains that can be controlled to release great quantities of energy.

The discoveries of these physicists laid the foundation for a new concept of the physical world. From their observations, 20th-century science has been able to expand its understanding of the structure of the atom. Scientists have used this knowledge in practical applications as diverse as power generation and medical treatments.

Since the Curies, though, the field of physics — particularly nuclear physics — boasts few such high-profile women. The tradition of a male-dominated profession remains in this scientific specialty. Few would deny this fact.

"It is, beyond a doubt, a struggle to attract suitable women to careers in science and engineering," laments Harry Hughes, corporate vice-president, human resources, at Atomic Energy of Canada Limited (AECL). But the situation is beginning to improve as more women opt to study science in university, he points out.

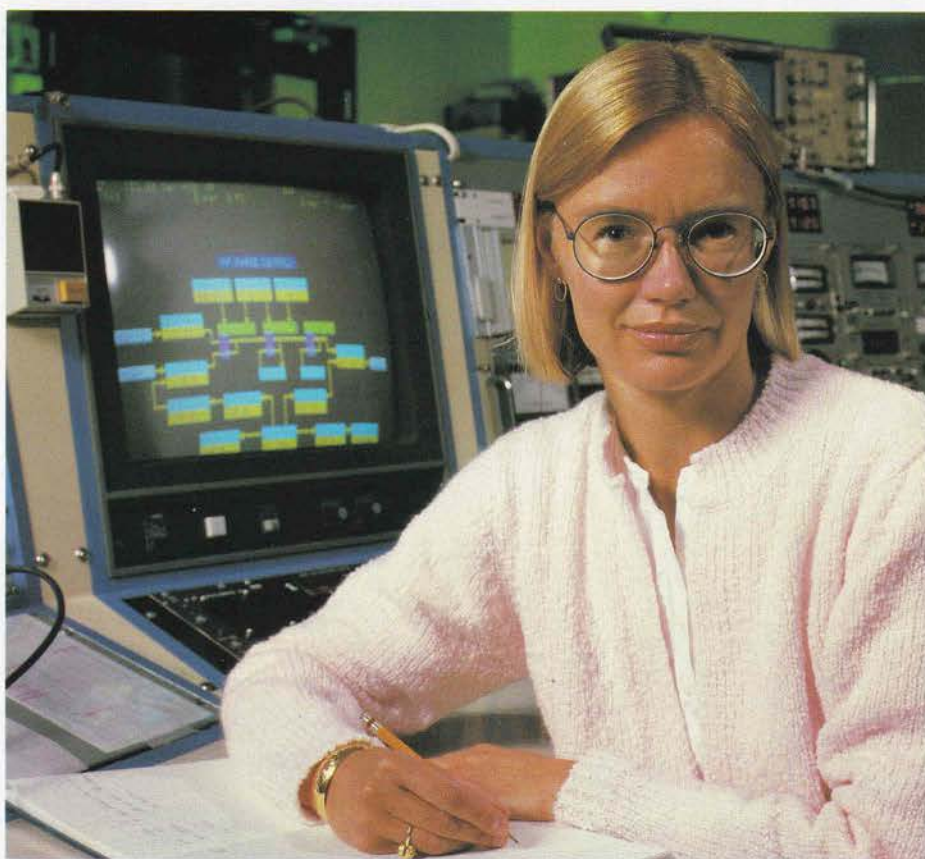
The percentage of female graduates in physical sciences at Canadian universities, in fact, nearly doubled between 1970 and 1987, increasing from 15 percent to 27.5 percent. And the percentage of female

graduates in engineering took an even bigger jump, increasing from 1.3 percent in 1970 to 10.6 percent in 1987.

The traditional lack of female graduates in science and engineering, in turn, can be traced back to high school, where science has not been promoted as a career option for females. As a result, they fail to take the mathematics and science subjects required

for example, found that when science teachers encouraged girls to study science, the interest in the subject and in pursuing scientific careers blossomed.

The experiment involved eight biology teachers. These teachers set up visually stimulating classrooms filled with posters, pictures, models, live specimens, equipment, and projects. They encouraged girls



*Helena Lindqvist, cyclotron scientist, Chalk River: "If I know everything, it just isn't fun anymore."*

for university or college entrance.

Studies, in fact, have shown that the attitudes and teaching methods of educators can have a profound influence on future career paths. A study in the United States,

to participate in class and they avoided sexist language and jokes.

After 12 months, male and female students were questioned about their attitudes toward science and science



careers. When compared with a national sample, all the students in the study had a much more positive outlook, but the difference was especially pronounced among girls. When asked how frequently they like to attend science class, 67 percent of the girls in the study said "often" compared with 32 percent in the national sample. And when asked if they would like to go into a science career, 65 percent of the girls in the study said "yes" compared with 32 percent of the girls in the national sample.

While science has not been a traditional career choice for female students, there are examples of women who have carved out successful careers as scientists. Helena Lindqvist, Joan Miller, Eva Rosinger, Basma

colleagues in the scientific community.

These women are firmly committed to the principle that science is not just a male preserve. Each has, at one time or another, talked to female students in high school or university about the allure of science and its rewards as a profession. Still, men continue to outnumber women in scientific careers, as they always have.

Lindqvist, for instance, is the only woman scientist working in the nuclear physics building at the Chalk River Nuclear Laboratories. But after nearly five years there, she has come to realize that minority status comes with the territory. "You may be noticed more or remembered a little longer when you're the only female scientist

Lindqvist's view. "People hired (into professional positions) at AECL are measured on the basis of what they can do as scientists and engineers. And women have done exceptionally well in this regard."

## Helena Lindqvist

Helena Lindqvist's career at AECL could be termed a smashing success. She works at the Chalk River laboratory helping to ensure that a crucial experimental device — the Tandem Accelerator Superconducting Cyclotron (TASCC) or, as it is more affectionately called, an atom smasher — functions properly.

Researchers use TASCC to probe the nucleus of the atom in search of nature's fundamental building blocks. TASCC hurls atoms at one another at exceptionally high speeds. Scientists stand by with sophisticated electronic detectors to collect the particles and radiation that result from the collisions. Then, by analysing the radiation and measuring particle speeds, direction, and types, they look for clues to the innermost nature of atoms and the forces that hold them together. This is basic research important to understanding the atomic nucleus and the energy it releases, a for example, in powering a nuclear reactor.

Lindqvist's speciality is the cyclotron. "I calculate the settings of the cyclotron so that it will operate at its peak," she says.

A physicist by training, Lindqvist, 40, has more than 15 years of experience working with cyclotrons. In Sweden, where she worked after receiving her master's degree, she designed cyclotrons for a company that manufactured them commercially. She moved to the Chalk River area in 1982 with her husband, an AECL employee she met while he was working in Sweden.

Being the only woman in her area at AECL has its pros and cons, says Lindqvist. "On the positive side, people are not as hard on me as they are on some of the men and I can be more straightforward in presenting my ideas. But on the negative side, it's frustrating not to be always taken seriously — sometimes it's a bit tiring when I have to prove 20 times over what others hardly have to prove at all."

Lindqvist recalls she never expected to work in the nuclear industry. "But this job with TASCC is very interesting and is exactly in my field. I certainly have to draw

(Continued on page 25)



Joan Miller, group leader, tritium technology lab, Chalk River: "It's a different way to apply my scientific knowledge creatively."

Shalaby, Simcha Stroes-Gascoyne, and Bibianne Slade are six women who followed their brains and their hearts into scientific careers at AECL that challenge and excite them. They are asking important, imaginative questions about our world and getting answers no less often than their male

around," Lindqvist concedes. "But that adds nothing to scientific credentials. It's the quality of your research that counts."

Shalaby, manager of CANDU 3 process engineering at CANDU Operations in Mississauga, Ontario, and one of only a handful of female managers there, shares





## MAKING AN IMPACT IN THE WORLD OF SCIENCE

Rita Dionne-Marsolais is an economist, not a scientist, but as the Canadian Nuclear Association's (CNA's) vice-president of information, her job is to convey scientific information to Canadians. She does not believe that being a woman is either an advantage or disadvantage in her role. "Being a man or woman doesn't affect your credibility. And credibility is the most important asset to have in the job that I do," she contends.

Dionne-Marsolais built her credibility climbing the corporate ladder, first at Hydro-Québec, then as vice-president of the Société générale de financement du Québec, as president of Bio Endo Incorporated, and as Québec's Delegate General in New York from 1984 to 1987. At the CNA, she is responsible for a new, long-term program that addresses nuclear issues.

"When I joined the CNA, I was astonished to see how little Canadians knew about the CANDU reactor, which is probably our country's greatest technological achievement."

Dionne-Marsolais firmly intends to change that situation. She has an annual \$2 million to \$3 million budget to educate Canadians on the benefits of nuclear energy. "Our ads feature the same number of men and women. The ads are thus truly representative of Canadian society, and in particular, of the men and women who work in our industrial sector."

But, she adds, men and women do differ on their views of nuclear technology. "Men talk about nuclear issues in neutral terms, while women want to see a humanization of technical concepts."

Dionne-Marsolais is one of a growing number of women who are making an impact in Canada's scientific community. Sylvia Fedoruk and Raymonde Chartrand are two others.

Sylvia Fedoruk, a radiation physicist for more than 35 years, is now Lieutenant-

*Rita Dionne-Marsolais, the Canadian Nuclear Association's vice-president of information, spearheads the effort to educate Canadians on the benefits of nuclear energy.*



Governor of Saskatchewan. Although she no longer works directly in nuclear physics, she still tries to be a role model for young girls considering careers in science.

"I want to help change the signals that girls receive in the classroom about their abilities in math and science. Real girls do study math," Fedoruk insists.

She studied radiation physics when the field was new, when few women went to university, and even fewer studied science.

Throughout her years at the University of Saskatchewan, where she earned both bachelor and master's degrees, Fedoruk was the only woman in her class.

Nonetheless, it was an exciting time to be involved in physics, she says. "Those were the pioneering days for the development of applications for Cobalt 60 and for the use of high-energy radiation in cancer treatment. I consider myself lucky to have been a part of that."

After graduation, Fedoruk joined the Saskatchewan Cancer Foundation where she worked, developing radionuclide detectors, until 1986. She also sat on the Atomic Energy Control Board from 1973 to 1988.

Like Fedoruk, Dr. Raymonde Chartrand is a pioneer. Now head of the Nuclear Medicine Department at Saint-Luc Hospital in Montréal, she was only the second woman doctor there when she arrived at the hospital in 1969. "Because there were so few women I stood out more. I felt I had to be better just to be good," she recounts. "Certainly I felt that if I was a man it would have been easier. But I couldn't spend much time dwelling on the frustration; I was busy training to be a medical specialist."

### Changing times

But times are changing, she acknowledges. Chartrand, who chairs the specialty committee in nuclear medicine for the Royal College of Physicians and Surgeons of Canada, believes medicine, as a profession, is attracting more and more women. For instance, she says, there are currently more women than men at the University of Montréal's medical school. And 7 of the 15 student physicians training to become nuclear medicine specialists in Chartrand's department are women.

Nuclear medicine uses radioactive tracers — a liquid, pill, or a gas containing a radioisotope — to diagnose disease. After injecting the tracer into a patient, Chartrand uses computerized scanning devices to detect the tracer and generate detailed pictures of various organs in the patient's body. She chooses different tracers, and sometimes different cameras, according to the particular organ she wants to investigate. Use of the tracers and scanning devices often eliminates the need for exploratory surgery. (Nuclear medicine was described in an article in *Ascent*, Volume 7, Number 4).

Like other women working in the nuclear industry, she has no concerns about the safety of the processes that she works with. She worked in nuclear medicine through all three of her pregnancies. She has a son and two daughters, one of whom expects to become a physician like her mother. ■



*Dr. Raymonde Chartrand, head of the Nuclear Medicine Department at Saint-Luc Hospital in Montréal, sees more women entering the medical profession.*



(From page 22)

upon all my experience in designing cyclotrons to operate this one and keep it working properly."

According to Lindqvist, AECL's cyclotron is particularly intriguing to work with now. "We're fine tuning it to handle some very specialized experiments."

But such challenges are welcome, she hastens to add. "If I know everything, it just isn't any fun anymore."

## Joan Miller

The route from scientist to manager is not a well-trodden path. Few individuals travel it. But, at 32 years old, Joan Miller

papers for conference presentations.

Miller clearly enjoys the changes in her career. "It's a different way for me to apply my scientific knowledge creatively," she says. "And the change can only lead to new achievements."

Miller, a chemist, heads up the Tritium Technology section in the Chemical Engineering Branch at Chalk River. She directs the activities of eight engineers, scientists, and technologists in the operation of the tritium lab and associated R&D programs.

Tritium is a radioactive isotope of hydrogen. It forms in the cooling water of the reactors as a regular byproduct of CANDU operations. Although tritium

emergency and remote light sources.

Ten years ago when Miller joined AECL, the company was just launching the program to remove tritium from operating reactors. "It was, at that time, a new activity in reactor operations," Miller recalls.

"Processes and systems were required to collect, package, and handle the tritium."

Miller's group developed the technology that packages the tritium gas removed from the CANDU systems in the form of a metal compound. They also have demonstrated the handling and monitoring techniques required for this new byproduct. In fact, the tritium packaging facility developed by Miller and her staff is used at the Chalk River tritium extraction plant.

This team has helped AECL gain an international reputation for its expertise in tritium technology. "Our lab is one of the few in the world that can handle large quantities of tritium," Miller explains. "The international fusion community relies on Canada for advanced tritium expertise."

Miller was one of the first women scientists at Chalk River, but she says that she never really noticed it then. "I never felt any pressure to compete on a different level than my male colleagues," she says.

Miller also says she paid little attention to the fact that she was one of very few women in her courses at university. "It never occurred to me that science was an unusual field for me to be in."

AECL hired Miller after she graduated with an honors bachelor of science degree from McMaster University in 1979. A chemist by training, she had little direct experience with tritium. However, she felt she had enough background to learn what she needed to know. "I didn't study tritium chemistry in university," she acknowledges. "But I was confident that I could adapt my education to any new chemistry environment."

From her accomplishments, obviously she was right.

## Eva Rosinger

When the Canadian Nuclear Society met in Ottawa this summer, Eva Rosinger became only the second woman in its 10 years of existence to be named president.

Rosinger, however, is getting used to setting precedents in the nuclear industry. She has been executive assistant to the president of AECL, head of AECL's environmental and safety assessment



*Eva Rosinger, director, AECL Waste Management Concept Review Office: "I keep finding myself in brand new positions for which there is no modus operandi to fall back on."*

has progressed to the position of group leader at AECL. Now, much of the time she once spent at the lab bench conducting experiments is occupied supervising technologists, interpreting other scientists' data, developing technical programs and experimental models, and coordinating

releases very weak radioactivity — not nearly as penetrating as the rays emitted from radioactive fuel — it still requires special packaging and handling techniques. Tritium is a valuable substance, useful in fusion reactor research, as a radioactive tracer, and as the power source for



branch, scientific assistant to the director of the waste management division at AECL, and head of the systems assessment section in the company — all within just the last decade.

Now Rosinger is the director responsible for managing AECL's preparation for an upcoming federal review of the nuclear fuel waste management concept. "I keep finding myself in brand new positions for which there is no *modus operandi* to fall back on," she says. "Although that can be sometimes stressful, it is also very challenging and exciting."

Rosinger joined AECL in 1973 as a part-time technician to do modeling of chemical processes. She recalls that the competition

science degree in chemical engineering and a doctoral degree in polymer science, credits her parents with building her self-confidence. "My parents challenged most of my decisions. It wasn't actual opposition; they just wanted to make sure I knew what I was doing. I learned to defend myself. But when they realized I was serious, they gave me full support."

Like many of the women professionals working for the research company, Rosinger is married to an AECL scientist. Their twentieth wedding anniversary is this year, and Rosinger considers herself "very fortunate to have a supportive spouse who recognizes my career aspirations are as important as his own."

Whiteshell laboratory in Manitoba. "There was no reason for either of us to pass up those opportunities," she says.

Aside from her work, Rosinger, 48, is an accomplished cross-country skier and an orienteering expert, having won several provincial championships and one national championship. Competitive sport builds character, she believes. "Sports teach you to train, to plan, to execute plans, and in some cases to fail. And it teaches you the value of teamwork. These are all important experiences for growth."

Rosinger says she was helped by several mentors at AECL. "They certainly provided valuable advice and guidance once I proved that I could handle the job."

It's a measure of her success that she is listed in such impressive volumes as *American Men and Women in Science*, *Who's Who in Canada*, *5,000 Personalities of the World*, and *Who's Who of Canadian Women*.

"I'm not afraid to be visible," Rosinger says. "I work hard and appreciate people knowing that. But mostly, I simply pursue my career without too much fuss."

## Basma Shalaby

"Facing a difficult engineering task is a challenge," declares Basma Shalaby. "But the sense of accomplishment when the job is complete is intense. It renews my energies and I'm ready to go on to the next challenge."

Shalaby is the manager of process engineering at CANDU 3 Operations in Sheridan Park, Mississauga, Ontario. She heads the group of scientists and engineers responsible for developing the process and safety systems for the new CANDU 3 reactors, including such key components as the heat transport, moderator, liquid injection shutdown, and emergency core cooling systems. The work also encompasses stress analyses and equipment specifications for the reactor components.

"It's a demanding job," Shalaby says. "The hours are long and the work arduous at times. But it's certainly not boring, and the job has both material and psychological rewards."

Shalaby, 38, joined AECL in 1975, after graduating with a master's degree in chemical engineering from the University of Waterloo. She admits she hadn't looked specifically to the nuclear industry for employment, but her degree thesis pointed her in that direction.



**Basma Shalaby, manager, process engineering, CANDU 3 Operations, Mississauga:** "You have to nurture your career all your life."

for jobs was fierce at the time and admits that it was a challenge as a woman to become accepted as an engineer and scientist. "But I worked at overcoming that," she says. "I wasn't going to allow myself to be limited by stereotypes."

Rosinger, who holds a master's of

That recognition has sometimes meant they have had to work apart. For instance, Rosinger spent 18 months on assignment in Ottawa on her own two years ago, and some years before, her husband spent six months in Germany as a visiting scientist while Rosinger continued her work at AECL's



She was studying the combined mass and heat transfer between steam and dousing water, Shalaby recalls, and found she could apply her theoretical calculations to the condensation of steam in reactor buildings. "AECL became interested in this research," she says, "and offered me a job in the process engineering department as a member of the scientific staff."

Now, 14 years later, she manages that same department. Currently, her group is participating in the efforts to advance CANDU technology for the CANDU 3 series of reactors. "CANDU 3 is designed to be a state-of-the-art, cost-competitive product," she states. "From an engineering perspective, that has meant finding ways to

reactors merge mechanical and chemical components into a single system. Being part of the design team for this kind of system applies nearly all the engineering principles I was taught. For me this is the real meaning of engineering."

To accomplish what she has, she maintains a practical philosophy. "I make it a point to stay on top of my work. I set goals and priorities, and I work at maintaining the self-discipline to meet them," she says. "It's difficult sometimes because I'm also committed to my husband and two young children. But I've been keeping up for almost 15 years now, and I expect to continue doing so."

Shalaby confides that she treats her

looked up to him. We talked about his projects and about our individual aspirations and dreams. He was an important role model for me as I was growing up."

Later, Shalaby found mentors in her managers and supervisors. Regrettably, she says, she has had no women to emulate. Even today, there are a few women in the field. In fact, of the 24 engineers and analysts who are in her group, only one is a woman.

Shalaby, however, believes that will change with the steady increase in the number of women entering science and engineering during the last decade. To encourage female students to enter the field, she endeavors to maintain a fairly high profile during AECL's hiring drives. "My career in engineering is rewarding and my experiences at AECL have always been positive. I want other women to see a similar career as a real possibility for them."

### Simcha Stroes-Gascoyne

Four years ago, Simcha Stroes-Gascoyne, then a full-time engineer in the waste management program at the Whiteshell Nuclear Research Establishment in Pinawa, Manitoba, became the first permanent part-time scientist on the AECL payroll. That pioneering step has allowed her to merge a scientific career with the demands of a growing family.

For scientists, abandoning a career for even a few years to raise children can spell disaster, she acknowledges. Science changes rapidly and scientists must stay current with the latest knowledge. At the same time, she didn't want to sacrifice her family to her career. "The arrangement with AECL is working out extremely well," she says. "In the morning, I give myself totally to my work. In the afternoon, I spend time with my children."

Stroes-Gascoyne, 37, has been involved in a variety of geochemical and environmental studies, either at AECL or at university. She holds a master's degree in environmental engineering from a university in her native Holland and a doctoral degree in civil engineering from McMaster University in Hamilton, Ontario.

"I have a fairly diverse background," she concedes. The key, she says, is that she has "learned how to learn." Her scientific education, she explains, has given her the skills to understand new information, even if it is outside her area of formal training.



*Simcha Stroes-Gascoyne, scientist, AECL Waste Management Program, Whiteshell: "It's very fulfilling to have our work appreciated internationally."*

capitalize on the proven strengths of existing CANDU systems while at the same time adding new technological advancements."

For Shalaby, work on the CANDU reactors represents an ideal application of her engineering training. "CANDU

career like another child. "You have to nurture your career all your life. If you don't, you'll find that it's not yours any longer."

Shalaby's father, an engineer like his daughter, played an important role in helping shape her life, she says. "I always



Stroes-Gascoyne now is part of the AECL Waste Management Program that is investigating the feasibility of permanent geological disposal of spent nuclear fuel, using a multi-barrier approach. Her work involves the evaluation of spent fuel as a radioactive waste form. She designs experiments to investigate how much, and how fast, radioactivity would be released if spent fuel were to come in contact with groundwater.

"It is particularly interesting to be working in this field," she says. "We have to understand the complex nature of spent fuel and the reactor conditions under which the fuel is burned in order to assess how it might release radioactive products under a

worldwide research on spent nuclear fuel. "It is very fulfilling to have our work appreciated internationally," she says.

Overall, Stroes-Gascoyne says she finds her career in science very rewarding. "I have an unusual and interesting job," she notes, "and I enjoy looking for extra challenges, especially when it comes to interpreting information from experiments."

Scientists can collect lots of data, she explains, but they still have to choose appropriate analyses to make experiments worthwhile and to ensure that the conclusions are valid. "This is an area where I particularly want to demonstrate my capabilities," she declares.

Stroes-Gascoyne admits that she

However, Stroes-Gascoyne says she feels that her choice to become a scientist and to work part time has paid off. "I enjoy my job, I'm contributing to an advancing field of science, and I have the right balance of career and family life."

## Bibianne Slade

In January 1988, Montréal native Bibianne Slade became, at the age of 27, the first woman in North America to be put in charge of a nuclear reactor. As one of the senior shift supervisors at the National Research Universal (NRU) research reactor at Chalk River, she directs the work of 3 engineers and 15 operators.

The NRU research reactor is used to produce radioisotopes for medical uses and for research and development in support of the nuclear reactor program, including safety experiments for Ontario Hydro and the U. S. Nuclear Regulatory Commission.

"When I was hired, I got a lot of attention and it was fun. But it didn't stop, and then it became tiring," she reflects. "Although my supervisors were always supportive, some men had a bizarre attitude toward me. One man, for example, asked me if I was a woman who had come to the Chalk River lab to compete with men. I replied, 'No, I'm here to work with them.'"

Although it was not unusual at the time for someone so young to be named a shift supervisor at Chalk River, it was unusual for a woman to be given such responsibilities. "Other women have been hired in my department since, but they don't get as much attention as I did when I was hired," she says. "I guess I broke the ice."

Slade adds that she does not have concerns about working so closely with a nuclear reactor. "I feel safer than I would if I was working with many products in the chemical industry."

A chemical engineer, Slade studied at John-Abbott College in Montréal, Mount Allison University in New Brunswick, and the Technical University of Nova Scotia before joining AECL in 1984.

She says she has set no limits on her career ambitions. "I don't know how my career will progress, but I expect to work for a long time with AECL. People who have experience running reactors are sought after everywhere in the company, and I know there are doors open for me at AECL." ■  
*Rhonda Birenbaum is an Ottawa-based freelance writer.*



**Bibianne Slade, senior shift supervisor, NRU research reactor, Chalk River:** "I know there are doors open for me at AECL."

variety of disposal conditions." This work will help other scientists in AECL's Waste Management Program to evaluate the concept of permanent burial of spent nuclear fuel.

According to Stroes-Gascoyne, Canada is considered to be in the vanguard of

sometimes feels the pressure of being not only a female scientist but a part-time employee in a traditionally male-dominated field. "Although working part time could mean slower career growth, being a female should have no bearing on the assignments I can handle."





# THE PUBLIC VIEW ON ENERGY CHOICES

*Reliability of supply and concern for the environment are the key issues in weighing options for new electricity-generating stations in Ontario.*

by Michael Kirby

It is important for people who deal with energy issues — industry representatives, spokespersons for special interest groups, and politicians — to understand the concerns of the general public and the values that they want the public and private sectors to apply in making energy choices.

In Ontario, surveys have shown people believe that an extremely reliable energy supply and a clean environment are two of the most important factors affecting their quality of life.

If you ask Ontarians what they value most, other than good health and a close family, it is owning their own home and as many as possible of the appliances which make living in it comfortable. For Ontarians to achieve their goals, they need not only a good job and significant income, but also adequate energy to heat and air condition their homes and operate its appliances.

Ontarians also believe that abundant, reasonably priced energy is required for another reason — to enable the economy to keep expanding and to ensure continued growth in employment.

When Ontarians are asked to rate a series of public and private sector services, they rank electricity first, with virtually every single Ontarian saying that electricity is an essential service. It is because of the central role which energy plays in making possible the achievement of the average Ontarian's desired lifestyle that reliability of energy supply is considered so essential.

At the same time, however, in the past two years there has been a doubling of the number of people who believe the province has less generating capacity than it needs. There also has been a corresponding increase in the level of insecurity and concern about electricity supply. The issue of adequate electricity supply in Ontario is on the verge of becoming a major public and political issue.

Industry, in particular, is becoming very



**Michael Kirby:** *"The issue of adequate electricity supply in Ontario is on the verge of becoming a major public and political issue."*

concerned about the electricity supply problem and its potential impact on its future investment decisions. Industry is now starting to believe its investment plans may have to be curtailed if an increase in electricity is not achieved soon.

Reliability of electricity supply, then, is a key issue with Ontarians. Another key issue is the environment. Concern about the environment is not just a passing fad. It has become deeply ingrained in the value structure of the average Ontarian, particularly among those who are under the age of 35. The importance of a clean environment as a public policy issue is here to stay.

Ontarians, however, will not accept the proposition that the environment needs to be made worse if they are to achieve a better standard of living. This trade-off is one which Ontarians believe they should not have to make. They want to achieve both objectives.

A clean environment and energy supply are linked through the impact that generating electricity can have on the

environment. Because Ontarians want both a reliable supply of electricity and a clean environment, they are prepared to pay higher electricity rates to achieve them.

## Energy conservation

Study after study of public attitudes on energy conservation, however, show that relatively few Ontarians are prepared to make a significant sacrifice in terms of the amount of energy they use, or the time of day they use it, in order to reduce overall energy demand and thereby reduce the need for new energy projects, including electricity-generating projects.

The reluctance of Ontarians to participate massively in conservation projects is due to several factors. First, they do not believe that the actions of a single individual can have significant impact on overall demand and hence the need for, or timing of, new electricity-generating projects.

Second, they believe that electricity is reasonably priced, and so if they were offered a price incentive to reduce demand, or shift the time of day of demand, the amount of money they would save is relatively insignificant in comparison with the inconvenience which would result from changing their current demand pattern.

While financial incentives would have an impact on the amount of electricity consumption, the size of the financial incentive which would be required to persuade people to take an electricity conservation program seriously — an incentive in the range of 20 to 25 percent of current cost — means that a financial-incentive-based program would be fiscally infeasible for an electrical utility to offer.

Third, there will be an extremely strong public reaction against any attempt to mandate an electricity conservation program. The public believe that mandatory programs are wrong and that participation in any such program must be voluntary. In essence, the public believe that government should not dictate the value changes which would be the result of a mandatory electricity conservation program, but that it



is acceptable for government to offer incentives to persuade the public to change their values. Incentive-based demand management programs are acceptable; mandatory ones are not.

Finally, when Ontarians are asked what they think the term "energy conservation" means, in almost equal numbers they give two distinctly different definitions. Half the population say that it means using energy wisely, more efficiently, and getting better value for money. The other half of the population say that it means doing without, suffering, and not having the things they want in life. The second meaning of the term "energy conservation" is very negative because it suggests to average Ontarians they will not be able to achieve the material things in life which they value so highly, and for which they work so hard.

It is important to understand that when we use the term energy conservation we are sending out two distinct messages. One is the message of efficiency and value for money, which is a very positive message. The other is doing without the things we want in life, which is a very negative message.

## Energy options

When Ontarians are asked to rank potential sources of new electricity generation, the preferred alternative is hydro power, which many in Ontario, particularly those in Southern Ontario, believe the province has in abundant, untapped amounts. There is an erroneous perception that much of Northern Ontario consists of untapped rivers and lakes which could be dammed and used for electricity generation at virtually no environmental cost.

When the hydro option is removed from consideration because it is not feasible, we are left with four other means of generating electricity — natural gas, nuclear power, purchased power, and coal.

No matter how the question is asked, coal-fired generating stations are the worst of the four alternatives as far as the public are concerned. People believe that coal is the major source of acid rain, and acid rain is the number one environmental concern of Ontarians. New coal-fired generating facilities, then, run directly counter to the desire for a clean environment.

Purchasing power from Québec or Manitoba ranks third. While the public sees

advantages in using purchased power — primarily that the environmental costs of electricity generation would be moved out of the province — they also see one significant drawback to the purchased power option: its impact on reliability. Purchased power would put control of Ontario's electricity supply in the hands of people living outside the province, and that makes people nervous if it is done to too large an extent.

The preferred source of electricity generation, ranking slightly ahead of nuclear-powered stations, is natural-gas-fired generating stations. The reason is that the public believe that natural gas generation is safe, clean, and in abundant supply. There is, as yet, no linkage in the public mind between the burning of natural gas and the emerging environmental problem of carbon dioxide or the greenhouse effect.

The nuclear option generates the most emotional response. The public are divided right down the middle on nuclear power:

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### ***New coal-fired generating facilities run directly counter to the desire for a clean environment***

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50 percent favor building a new nuclear power plant and 50 percent oppose such construction. Moreover, among those opposed, 30 percent say they would strongly oppose such a plant.

There are essentially two reasons why Ontarians are concerned about nuclear power: nuclear waste; and plant safety — the fear that a Chernobyl or Three Mile Island type of accident could occur.

There are two interesting observations that can be made on the nuclear power issue. The first is that far more people believe that Ontarians are opposed to a new nuclear power plant than are actually opposed to it. Indeed, the public perceives the opposition to a new nuclear power plant to be 30 percent greater than it actually is. Equally interesting is the fact that three-quarters of Ontarians believe that construction of a new nuclear station is inevitable.

## Demand management

Against this background of public attitudes toward electricity supply options in which the most acceptable option —

hydro power — is not feasible, and in which each of the other four options are regarded with varying degrees of misgiving, one must inevitably address the issue of whether demand management is not the solution to the need for new electricity supply.

Demand management is seen as a very positive thing, but only to the extent that focusing on it, thereby delaying construction of new electricity-generating facilities, does not put at risk the reliability of energy supply. When surveyed, half the respondents say that the primary focus of government policy should be on increasing supply, one-quarter say that it should be on decreasing demand, and one-quarter say that it should be equally on increasing supply and decreasing demand.

Respondents make it clear that their concern with excessive reliance on demand management is the risk that it will lead to a situation in which the forecasted level of electricity saving is not achieved, and because inadequate attention has been given to increasing the supply, there will be a supply reliability problem.

Meeting the challenge of providing a reliable, environmentally acceptable supply of electricity will not be easy because whatever decision is made will spark significant public debate.

What is clear, however, is that the public do not want an electricity supply problem to develop. Nor do people want the future reliability of electricity supply in Ontario put at risk through years of wrangling before regulatory agencies or the courts. Equally, the public are getting increasingly tired of simplistic, ideologically based answers which are frequently put forward by both industry and special interest groups.

The people in Ontario face a very difficult choice with respect to the nature, and the timing of construction, of future electricity-generating facilities. The time has come for a significant public consensus building on this tough public policy problem. ■

*Senator Michael Kirby is vice-president of Goldfarb Consultants, a major market research and public opinion polling company based in Toronto. Senator Kirby was appointed to the Senate of Canada in 1984. This Viewpoint was excerpted from a speech Senator Kirby made to the Conference on Ontario's Energy Choices earlier this year in Toronto.*





*AECL will prepare a master plan for a Process Technology Laboratory that will be located in this building in Indonesia to support strategic industrial development.*

## AECL preparing plan for Indonesian development

Atomic Energy of Canada Limited (AECL) has won its first overseas non-nuclear contract, helping Indonesia prepare a master plan for a Process Technology Laboratory that will support strategic industrial development.

The facility will consist of a complex of laboratories for pilot-scale industrial processes in food and agricultural product upgrading; organic commodity chemicals such as resins for paints, adhesives for wood, and polyester for fabrics; precious inorganic chemicals, such as silicon, indium, gallium, and rare earth metals; catalytic processes to support oil refining, fertilizer, petrochemical, and other industries; and oil-field chemicals used in the drilling, production, and transportation of petroleum.

The project will be undertaken by a joint AECL Research Company/CANDU Operations Montréal team, with support from the Canadian International Development Agency. Preparing the master plan involves defining the mission of the laboratory; identifying Indonesian industries that would benefit from its operation; developing a basic design for the physical layout, staffing, and equipment for the complex; preparing a financial plan for preliminary construction; identifying staff training needs; and preparing a plan for the first five to ten years of operation.

The facility will be located in Serpong at the Puspiptek Applied Research Park,

which is also home to the BATAN nuclear research centre.

If Indonesia decides to implement the plan, AECL will be in a position to bid on a project, similar to the BATAN project, worth as much as \$25 million.

## Environmental company seeks global markets

A new company has been set up in Canada to produce environmental goods and services for global markets using technologies developed by Atomic Energy of Canada Limited (AECL) and expertise

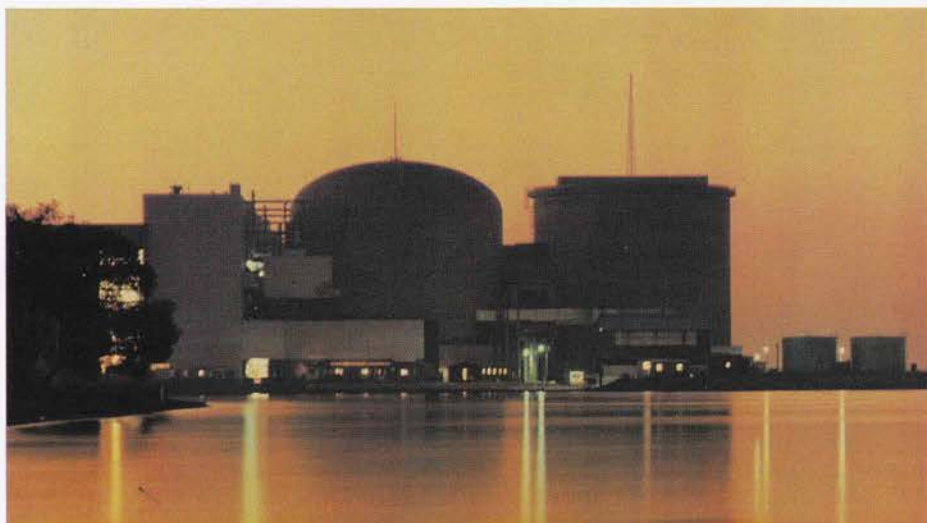
gained through AECL's \$50 million a year environmental research program.

Envotech, an independent company based in Manitoba, could become operational before the end of the year. Established by AECL in cooperation with the private sector, Envotech's world-class R&D program will support the production of monitoring, control, and cleansing equipment, as well as services related to environmental assessment, management of industrial environmental stress, technology transfer and training, and standards development.

## Nuclear increases share of electricity generation

During 1988, the quantity of electricity generated by nuclear power stations in the Organisation for Economic Co-operation and Development (OECD) countries rose by 8.9 percent, according to the annual survey recently completed by the Nuclear Energy Agency. Nuclear power provided 23.5 percent of electricity generated in OECD countries, up slightly from 1987.

Nuclear energy in 1988 represented about 70 percent of the total electricity production in France, 66 percent in Belgium, 47 percent in Sweden, 37 percent in Switzerland, 36 percent in Finland and in Spain, 34 percent in the Federal Republic of Germany, 27 percent in Japan, 19 percent in the United States and in the United Kingdom, and 16 percent in Canada. ■



*Nuclear power plants, such as the multi-unit CANDU station at Pickering, now provide 23.5 percent of the electricity generated in OECD countries.*



*Ascent*

